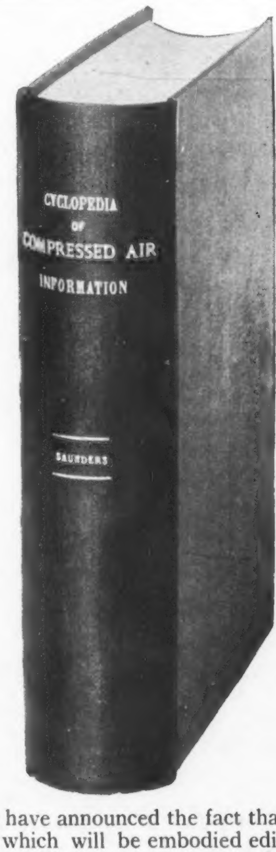
Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VII. NEW YORK, OCTOBER, 1902. No. 8.



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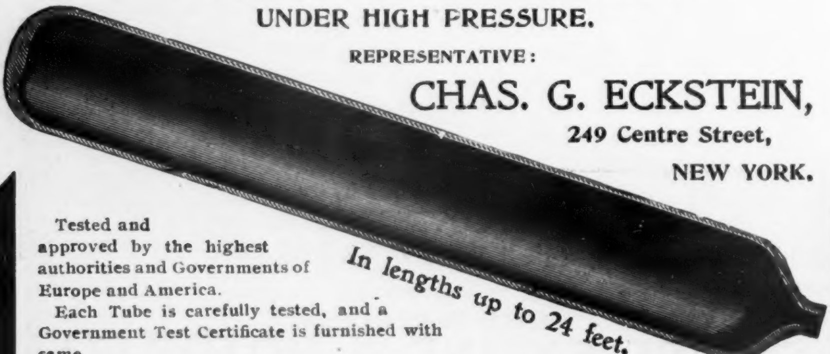

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The Use of Low Grade Oil and its Effect upon the Air Discharged from a Compressor.

In the present days of keen competition when work is being done upon a very narrow margin of profit, it has become necessary in every branch of business to economize and reduce to its lowest figure the cost of material and labor necessary to produce the required results.

This condition, with its many advantages over the more or less lax methods of former days, is apt to bias one's judgment in the endeavor to reduce as much as possible the immediate expenditures, with the inevitable results that many times what was thought to be a saving may cause, in the end, a great expense.

This is very aptly shown in the common practice of using a cheap grade of oil for lubricating machinery.

A very interesting phenomenon has recently been brought to light which was entirely due to this cause.

The readers of this paper may remember seeing some time ago a very complete article which described the methods of construction of the Rapid Transit Tunnel now being driven under Boston Harbor, between Boston proper and East Boston. In this work it has been necessary to maintain an air pressure, starting from a few pounds and increasing as the tunnel reached lower levels, until at the present date a pressure of approximately 25 lbs. per sq. in. is required.

As the tunnel increased in length and the accompanying necessity of carrying a higher air pressure, it was found that the air became more and more impure, until the conditions became so serious as to appreciably affect the working capacity of the men, making them drowsy and greatly affecting their endurance.

Tests taken at the time of the air in the tunnel showed a very large proportion of carbon dioxide. Every means that could be thought of was employed, with no appreciable results, in an endeavor to overcome this difficulty. Lime was placed around the floor of the tunnel to absorb the CO_2. The intake air pipes to the compressors were led without the station and a practicable means of artificially supplying oxygen was being contemplated, but, fortunately, before this had been undertaken, the trouble was practically remedied in a very simple manner.

Here it may be advisable to explain of what this plant consists. Besides the necessary boilers, etc., there is one 20 in. and 18¼ in. and 12¼ in. by 12 in. Class "A" Compound Steam Driven Air Compressor, which delivers air at 120 lbs. pressure to the winding engine that is placed within the tunnel and used to draw up the loaded cars. The exhaust of the engine is led into the side wall drifts. Besides this high-pressure machine there are three low pressure compressors, discharging into the main supply pipe which leads to the face of the tunnel.

What greatly perplexed the engineers was the fact that an analysis made of the air when taken near the discharge pipe from the machine seemed to contain a greater percentage of CO_2 than tests made of air from other parts of the tunnel. This led to the thorough washing out of all the compressors with soap suds, in order to clean them of all oily deposits; after which an analysis showed the remarkable drop of over 20 per cent. of the CO_2, a high-grade, non-oxidizing oil being used.

Upon investigation it appeared that a cheap oil had been used for some time, with the natural consequence that with the high temperature of the compressed air a continuous oxidation or slow combustion was going on and the products of combustion, of course, were discharged with the air, making it almost inadequate to support life.

Machinery Department at the Düsseldorf Exposition.

On visiting this exhibition one is immediately impressed with the extensive scale on which the exhibits of many firms are carried out, and which could not have been made for the sole idea of advertising those particular companies, but with the idea of impressing the world at large with the resources for manufacture in the German Empire, and more particularly in the province of Rheinland and Westfalen. For instance, Frederick Krupp has his own building, in which is exhibited a complete propeller shaft for a large warship—battleship turrets, ship frames, many guns for marine and land service, with the projectile cartridges, etc., pertaining to each. A large exhibit of armor plate is also made, both new and tested; in fact, the exhibit sets out in an impressive way the vastness of his line of manufacture.

The "Bochumer Verein" and others have also exhibited in the same way, but one is still more strongly impressed by the spirit of "Germany for ever," when visiting the machinery halls, where the co-operation of the manufacturer and the mine owner is exemplified. Under the Harpner Bergbau A. G. exhibit, Hanel & Lueg, have a large pumping engine with triple expansion steam cylinders erected. This machine has the following sizes of cylinder (as given in an outlined drawing on the wall):

H. P. steam..........	950 mm.	(37.2")
Interm. steam	1500 mm.	(59.0")
2 L. P. steam	1650 mm.	(65.0")
Stroke	1700 mm.	(67.0")
R. P. M..............	60	

Capacity, 25,000 litres (6600 gallons) per minute from a depth of 500 metres (1650 ft.).

Under the exhibit of the same mining company, and built by Eisenhütte Prinz Rudolph, is a vertical compound hoisting engine equipped with conical drums.

The H. P. cyl. is 820 mm. diameter (32.3"); the L. P. cyl. is 1150 mm., diameter (45.5"); the stroke is 2600 mm., diameter (102.0").

This engine is capable of raising a net load of 4400 kg. (9700 lbs.) from a depth of 1200 metres (4000 ft.). In connection with this hoisting engine is erected a steel tipple with an exhibit of cages, cars, etc.

The steam engine exhibits are extensive and comprise many large engines, but one of the most striking features of the machinery is the evident high development of the gas engine for utilizing the waste furnace gases. Under this could be mentioned the following

"Gasmotorenfabrik Deutz" have a 1,200 H. P. engine connected to blowing cylinders. (The engine is duplex with two gas cylinders on a side and the two blowing engine cylinders parallel to the others are connected by extending the crank shaft, direct.)

A 350 H. P. gas engine is exhibited by Louis Soest & Co., m. b. H. This company advertises the engine as capable of developing 300 to 350 H. P., with waste furnace gases and 350 to 400 H. P. with generator gas. The machine was operating lightly loaded.

Next to the above is a 700 H. P. engine built by Gebr. Klein. This engine is connected to a set of rolling mill rolls through rope drive. The exceptional feature of this engine is that its explosion cylinder is double acting, one end being fitted with a stuffing box. The cylinder is 750 mm. (29.5") diameter and has a stroke of 1,300 mm. (51.0"). Rated speed is 85 to 90 R. P. M.

Next in order comes another gas engine of the same power connected directly in a

straight line to a blowing cylinder 1840 mm. (72.5") diameter. The common stroke is 950 mm. (37.4"). Revolutions, 100 p. m.

There were other exhibitors in this line, but not so important.

PRINCIPAL EXHIBITORS OF PERCUSSIVE ROCK DRILLS.

Rudolf Meyer:

One drill mounted on single screw column as a coal cutter, but with lever instead of Eisenbeis sector.

Two medium size drills mounted on columns.

One small drill on column.

One drill wagon complete with four large drills.

In this drill exhibit is an electrically driven air compressor mounted on a narrow gauge truck with the air receiver on a separate truck. Compressor capacity about 90 cu. ft.

One puncher coal cutter is also exhibited with the above. It has every appearance of being a new production on the general lines of Ingersoll-Sergeant and other cutters of this type.

Frölich & Klüpfel:

Two drills, medium size, mounted on column.

One drill, medium size, mounted on tripod.

One drill, mounted on column as a coal cutter with a lever instead of sector.

H. Schwarz & Co.:

Two medium sized drills on column.

F. A. Münzner:

Two drills mounted as coal machines with sectors.

Paul Hoffman & Co.:

Two medium sized drills mounted on one column.

One medium sized drill mounted on tripod.

One small drill mounted on shaft bar.

P. W. Dinnendahl:

One medium sized and one small drill mounted on one column.

Heinrich Korfmann:

One medium sized drill on column.

One drill, mounted as coal cutter with lever (no sector).

Duisburg Maschinen-Fabrik:

Two medium sized drills on shaft bar.

One medium sized drill on tripod.

Two medium sized drills on columns with arms.

Two medium sized drills on columns, one as coal cutter with lever, one as drill, sector shown separately.

One drill as coal cutter with sector.

Siemens & Halske—Electric:

One drill on tripod.

One drill on column.

Union (Marvin Drill)—Electric:

One drill in water tank shown in operation under water.

One drill on tripod.

Two drills on columns.

Gebrüder Sulzer:

One drill wagon with the usual hydraulic horizontal column and two Brandt hydraulic rotary drills mounted on it.

All of the above are in one drill hall where stone is delivered and many of the machines are shown in operation each afternoon.

Where the terms "medium size drill" has been used above, it refers to a drill corresponding in size to Ingersoll-Sergeant C or D; "small drills" to their baby, "large drill" to their F.

The coal cutter drills would come under the medium size.

The above exhibits are all in the special hall for rock drills, while Flottman & Co. have their exhibit in the main machinery hall in connection with an air compressor exhibit by Gebr. Meer. They have four or five drills mounted on one long column and also one "E" drill (80 mm.) mounted on a tripod. This "E" drill is allowed to operate by pounding with a stub steel on an iron block, the same as usually done in factory drill testing.

AIR COMPRESSORS.

The exhibit in this class of machinery is the strongest evidence that the German manufacturers are thoroughly aware of its importance and that they intend to place themselves in a position to meet the ever-increasing demand.

In looking over the compressors exhibited one might easily gain the idea that the German standard and aim was based on the following qualification and in the order given:

1. Noiseless operation.
2. Efficiency of operation.
3. Fine finish and appearance.

While these are given in order they should all be placed as first considerations as they are evidently so closely allied in the German mind.

In all the compressors exhibited it is hard to find one that makes more noise than the ordinary steam engine; all with one or

two exceptions have planished steel jackets around the air cylinders with the water connections made from the bottom of the cylinder, so that the pipe connections are practically invisible to the ordinary observer. All oiling systems can properly be called "systems," as they consist of pump arrangement with pipe lines running to all the different parts.

PRINCIPAL EXHIBITORS IN THE AIR COMPRESSOR SECTION.

Schüchtermann & Kremer, Dortmund:

One duplex double compound horizontal compressor of about 400 to 600 H. P. engine fitted with the drop cut-off poppet valve and the air cylinders with the Collmann "Oelkatrakt" poppet valve.

Rudolph Meyer, Mülheim:

One high duty duplex horizontal compressor with compound steam engine of the poppet valve type and compound air cylinders fitted with his newly patented "Plattenringventil." These valves are placed one at each end of the cylinder, top and bottom, for discharge and inlet respectively, so that the air cylinders present a very simple (uncomplicated) appearance. This compressor is for about 350 H. P. and works very smoothly. Ninety-eight per cent. vol. eff. is advertised.

Neumann & Esser, Aachen:

One horizontal double compound air compressor of about 200 H. P. in size. The air cylinders of this compressor were so thoroughly enclosed with planished steel that one could not ascertain what valve system was used.

Pokorny & Wittekind, Frankfort a/M.

These people have two medium large compressors exhibited. One horizontal half duplex compressor with tandem compound steam cylinders, which are also tandem to the one air cylinder which is for low pressure air on one end and high pressure on the other, the general principle being the same as our compound single-acting class "E's," but more compact. The capacity of this compressor was stated as 1,800 cu. mtrs. per hour, or say 1,000 cu. ft. per minute to 6 atm.

One vertical compressor having compound steam cylinder and two air cylinders (each compound) and for a rated capacity 3,500 cu. ft. was exhibited.

Th. Calow & Co., Bielefeld:

These people had a very neat looking horizontal double compound compressor exhibited and of about 1,000 cu. ft. capacity. The valve motion on the high pressure steam cylinder was of the Rider type.

The air cylinders were fitted with the Patent Strand system of valves, which is a Corliss intake with the popet discharge, these *discharge valves being set in the Corliss intake valve itself*, similar to Nordberg's American system.

Stahl & Eisen A. G.
Vormals Julius Soeding, Hoerde, i. W.

One horizontal double compound air compressor of about 150 H. P. capacity. This machine was fitted with Riedler air valves and the Stumpf system of drop cut-off poppet steam valves.

Gebr. Meer:

One horizontal double compound air compressor of 150 H. P., with poppet steam valves and a "Lenker Ventil" air cylinder.

There were several other compressors exhibited, but not so extensively, namely:

From Maschinenbau-Anstalt Humboldt, Kalk, a-Rh.
From Frölich & Klüpfel.
From Paul Hoffman.
From Jul. Soeding & Co., Heyde.

H. L. TERWILLIGER.

Compressed Air Haulage.*

A COMPARISON OF THE SEVERAL FORMS OF MOTOR HAULAGE—THE PARTICULAR ADVANTAGES OF COMPRESSED AIR FOR MINE WORK.

For underground haulage in large mines there is a choice of four methods: by mules or horses, or locomotives operated by steam, electricity, or compressed air.

Animal power, the most costly of the four, is often employed, to a limited extent, in collieries and elsewhere, in connection with one or other of the systems of locomotive haulage, for making up trains and handling the individual cars in and out of the mine workings. Steam locomotives for underground service are rarely used except in collieries, and then only for long hauls, where the trains are conveyed through tunnels or entries directly to the surface. Haulage by steam

* Written for *"Mines and Minerals,"* by Robert Peele.

locomotives is rendered practicable in collieries chiefly by the fact that the fuel is a product of the mines themselves, and is therefore chargeable at a low cost. Their principal disadvantage lies in the serious vitiation of the mine atmosphere, and interference with ventilation, caused by the discharge into the workings of smoke and gases of combustion. Obviously steam locomotives cannot be used in the presence of fire damp.

Locomotives propelled by electricity or compressed air divide between them a much wider field of operation. Both are applicable to mines of all kinds, whether collieries or metal mines; for either long or short hauls, from a few hundred feet to several miles; they may be employed underground in shaft mines where cars cannot be brought in trains through a tunnel to the surface, but must be hoisted on cages; and they do not vitiate the mine atmosphere, nor influence the direction of the ventilating currents.

Comparing compressed air and electric haulage, and omitting questions of cost of plant, there are three advantages possessed by compressed air: First, it may be used in collieries with perfect safety in an atmosphere charged with fire damp*; second, since the power is stored in the locomotive itself the compressed-air system of haulage is more flexible. The locomotives can enter all parts of the workings, wherever track is laid, far beyond the limit of the supply-pipe line, and are not, like electric locomotives, dependent upon wiring, which must accompany every foot of advance; third, it costs little or nothing when not in actual use, and its full power or but a fraction of it are equally available at all times. During the unavoidable periods of idleness of the locomotives no power is lost, because, although the compressor may continue in operation, it is engaged only in storing up power in the receiver and pipe line. It may be mentioned, also, that the exhaust of the compressed air locomotive discharges pure air into the workings, thus improving rather than injuring the ventilation. This, however, is a minor consideration. Both electricity and compressed air must be looked upon merely as transmitters and distributors of power, depending for their production upon either steam or water-power as a prime mover.

*While it is true that recent improvements in electric motors have done much to prevent the occurrence of serious sparking, it cannot be denied that some risk from this cause still exists, and, moreover, the possibility of sparking from a ruptured conductor can hardly be averted.

Arrangement of the System.—The essential parts comprised in the installation are: the air compressor, pipe line, charging stations and locomotives. The capacity of the system naturally depends upon the size and character of the mine and the output desired. Formerly it was customary, for mines worked through tunnels, to omit the pipe line altogether, and to charge the locomotive at intervals from a large receiver outside, near the compressor. At present, however, the pipe line is nearly always carried underground, and at one or more points charging stations are established. The location and distance apart of these stations is determined by the requisite length of haul and the storage capacity of the air reservoirs or tanks carried by the locomotives. It is evident that the last, or innermost, charging station must be at a point from which the locomotive can reach the end of its trip and return for a fresh supply of compressed air.

It is not necessary to provide receivers inside the mine for charging the locomotives, though this may be done if desired. The pipe line itself acts as a storage reservoir, and must be of a diameter which, in proportion to its length, will furnish a cubic capacity sufficient to charge the locomotive tank quickly without serious loss of pressure. In other words, when the locomotive is connected with the pipe line, and the charging valve opened, the pressure in the locomotive tank and in the pipe, on equalizing, should not fall much below the stated pressure which the locomotive is intended to carry. With this end in view, it is desirable that the volume of storage in the main (or main and receiver) should be at least double the reservoir capacity of the locomotive. When several locomotives are served by the same pipe line, it is rarely necessary for mine work to design the system for charging more than one at a time. The relatively slight drop in gauge pressure after charging is soon recovered by the compressor, which, excepting in some small plants operating a single locomotive, is kept in nearly constant operation. In case additional locomotives are required after the installation of the system, the same pipe line may still serve, provided the compressor is of sufficient size to charge it to full pressure at shorter intervals. The piping, which generally

varies in diameter between 3 and 5 inches, should be of the best material, with sleeve joints made with the utmost care to prevent leakage. It is advisable not to bury the pipe alongside the track, but to carry it entirely uncovered along one side of the tunnel or gangway, either on the floor or on brackets, so that leaks will at once attract attention and be stopped.

The charging apparatus for the locomotives consists of a short right-angled connection inserted in the air main by means of a heavy tee, Fig. 1. This connection projects from the main a sufficient distance for conveniently coupling to the charging pipe of the locomotive. It consists of two parts, as shown in the cut: a vertical, rigid branch, containing a strong, accurately fitted 1½-inch gate valve, and a short horizontal pipe, attached to the rigid upright by means of a ball-and-socket or flexible joint. The movable section is thus capable of being swung back out of the way when not in use. By an easily manipulated union it is coupled to the locomotive charging pipe. In the locomotive connection are two ball-and-socket joints, together with a check valve close to the tank. After coupling on the locomotive at the charging station, the gate valve is opened, whereupon the air pressure immediately forces together the parts of the ball-and-socket joints and makes a perfectly tight connection. As soon as equilibrium is established between the pressure in the air main and that in the locomotive tank the valve is closed. To break the coupling the compressed air remaining in the connection between the gate valve and the check valve on the locomotive must first be released. This is done by opening a small "bleeder valve," placed just above the gate valve. The joints then become loose and are readily manipulated. The time occupied in charging is very short (usually only a fraction of a minute), owing to the high pressure in the main and the relatively large diameter (1½ inches) of the charging pipe.

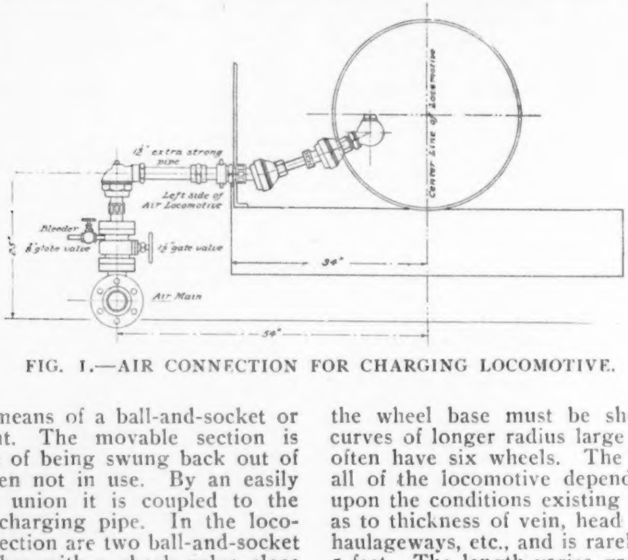


FIG. 1.—AIR CONNECTION FOR CHARGING LOCOMOTIVE.

Construction and operation of the locomotive.—For mine service, compressed-air locomotives carry either one or two cylindrical tanks for storing the air. These tanks, with the cylinders, piping, and other appurtenances, are mounted on a frame provided with springs similar to those of a steam locomotive, and supported by four or six driving wheels. Where there are sharp curves in the track, the wheel base must be short, but for curves of longer radius large locomotives often have six wheels. The height over all of the locomotive depends somewhat upon the conditions existing in the mine, as to thickness of vein, head room of the haulageways, etc., and is rarely more than 5 feet. The length varies greatly, mainly according to the capacity required, and the degree of curvature of the gangways. The tanks are cylindrical, with dished or approximately hemispherical ends, and are built of extra heavy steel plate, say ⅞ of an inch think. They are generally constructed to carry a working pressure of from 500 to 700 pounds per square inch, though it is customary to test them to 800 or 1,000 pounds. When extremely high pressures are required, tanks of large diameter cannot safely be employed, and

are replaced by a series of heavy steel tubes—for example, Mannesmann seamless tubes. Tubes of this kind, 9 inches in diameter and 11-32 of an inch thick, will carry working pressures of 2,000 to 2,500 pounds per square inch. A number of them are laid closely in a group, parallel to one another, and bound together by belts or straps. They are then inclosed in a light sheet-iron shell to protect them from wet and rust. Such high pressures are unnecessary for ordinary systems of mine haulage.

From the tanks the air passes into a small auxiliary or distributing reservoir, and thence to the cylinders. This reservoir is merely a section of 8-inch or 9-inch wrought-iron pipe, say 10 feet long, with closed ends, and is laid alongside the main tank. By means of an automatic reducing valve the pressure in the auxiliary reservoir is adjusted to the requirements of the engines. The cylinder pressure adopted generally ranges from 125 to 150 pounds per square inch, or say one-quarter of the pressure in the main tank. From the auxiliary reservoir the air passes through a balanced throttle valve to the cylinders. This arrangement permits the maintenance of a constant working pressure, prevents the waste of air which would be likely to ensue if air at full tank pressure were admitted to the cylinders, and makes the locomotive more manageable. The cylinders, moreover, need not be made so heavy as would be required for the high pressure. In starting a heavy load, excessive slipping of the drivers is avoided, and with light loads the reducing valve may be readily and quickly regulated to produce any required diminution of pressure in the auxiliary reservoir. For small scale mine work the air is sometimes admitted to the cylinders throughout nearly full stroke, and consequently, as the exhaust is at a high pressure, the efficiency is lower than it should be. This practice is doubtless due to the tendency to use as small a motor as possible for the service required, on account of the limited head room and narrow, crooked gangways so common in mines. Better economic results are obtainable, however, by using a cut-off and increasing the size of the locomotive and the weight on the drivers. This is most always done with large locomotives. Ample reserve power is available when necessary, since full tank pressure can be admitted to the cylinders in starting a heavy load, or in pulling on steep grades and sharp curves. In using the air expansively, as can be done with properly proportioned cylinders, there should be no trouble from freezing of the moisture. Although the cold developed will produce a low cylinder temperature, yet, as the initial working pressure is so much higher than is employed for pumps and other compressed-air machinery, the expanded air becomes relatively dry,† and the force of the exhaust would still be sufficient to keep the ports clear of accumulated ice. To this end the exhaust ports should be large, straight and short. If the high-pressure air from the main tank were used in the engines, both pistons and cylinders would have to be made excessively heavy, and any reasonable degree of expansion would produce a degree of cold difficult to deal with.

To calculate the motive power required, several factors must be known, viz., the tractive resistance of the loaded cars per ton on a level. the resistances due to gradients and curves, the weights of empty and of loaded cars, and the number of cars to be hauled in each train. The values of all these factors are known approximately or easily ascertained, with the exception of the resistance due to curvature of track. The latter has been determined experimentally for ordinary surface railways, but underground mine track is apt to be roughly laid, with curves of varying or irregular radius, and the elevation of the outer rail improperly adjusted. With sufficient weight on the drivers, however, sticking on a curve may be avoided by temporarily admitting air at full tank pressure, as noted above. In this respect compressed-air locomotives possess a material advantage over those driven by steam, in which the working pressure is practically constant. The average tractive force required per ton depends not only upon the condition of the track and roadbed, but upon the character and condition of the running gear of the cars. On level mine track it should usually be taken at from 30 to 40 pounds per ton, though the resistance may be considerably higher than this in starting the load. With track in exceptionally good condition, the tractive force may be as low as 20 pounds per ton. The grade resistance is 20 pounds per short ton, for

† In this connection reference may be made to an article by the writer in MINES AND MINERALS, April, 1902, page 411.

each 1 per cent. of grade. Colliery cars carrying 2½ to 3½ tons will weigh from 1,800 to 2,300 pounds, while those used in metal mines, where mechanical haulage is employed, vary between say 1,000 and 2,000 pounds. Many cars of the last named weight are in use in the iron mines of the Northwest.

With a given air pressure the capacity required for the locomotive storage tanks depends primarily upon the length of the round trip to be made with a single charge of air. When this distance is from, say, 1 to 1½ miles, the tank capacity generally varies between 50 and 150 cubic feet, according to the load, which, in turn, together with the track and grade resistances already referred to, governs the dimensions of the cylinders. Cylinders of 5 in. by 10 in. up to 9 in. by 14 in. are commonly used for mine service, the larger sizes being adapted for heavy work in collieries. Still more powerful locomotives are used for some kinds of surface work. In several installations, since 1897, at mines of the Philadelphia & Reading Coal and Iron Company, the compressed-air locomotives have been provided with compound cylinders. For long runs, of over 1½ miles, it is often desirable to increase the air pressure, rather than build tanks of very large size. Another plan, however, is to supply a tender which carries one or more additional tanks. Very long runs can be made in this way.

On account of the cold produced by the reduction of pressure from the main tank to the auxiliary tank, and to increase the efficiency of operation, reheating is found to be advantageous, though not essential. It may be accomplished conveniently by applying heat to the auxiliary reservoir. If steam be available a quantity may be injected into this reservoir each time the locomotive is charged. Or, in mines where there is no danger from fire damp a small reheating apparatus for burning oil or coke may be carried on the locomotive. When reheating is adopted, a quantity of water should be kept in the auxiliary reservoir. An incidental advantage of this arrangement is that the moisture from the hot water, which passes with the air into the cylinders, assists in lubricating the valves and pistons. The cylinders should not be lagged with non-conducting covering, as is so necessary for steam cylinders to minimize condensation. By exposing the surface of the cold cylinders to the warm air of the mine, some heat is absorbed and added energy is imparted to the compressed air. Sometimes the exterior surface of the cylinders is cast with corrugations, in order to present the largest possible surface to the warm surrounding air of the mine.

Compressors for Haulage Plants.—For compressing the air to the high tension required by compressed-air locomotives, the work must be done in at least three stages, and four-stage machines are sometimes employed.‡

When the mine is already provided with an ordinary low-pressure plant, for operating machine drills, etc., and which has some surplus capacity, a two-stage compressor may be installed, to take air from the low-pressure system and bring it up to the tension required for the locomotives. But, while some reduction in the cost of the plant may thus be effected, care must be exercised in making such a combination. If the quantity of air produced by the low-pressure system should at times be insufficient to furnish the necessary excess, at ordinary gauge pressure, for the locomotive charging compressor, the latter might be compelled to compress from too low an initial pressure. This would cause excessive development of heat, and, aside from the difficulty of maintaining proper lubrication, might possibly raise the cylinder temperature to the flashing point of the oil and cause an explosion.

It is always preferable to install an independent three-stage compressor for the haulage service. With such a compressor the final temperature can be kept down to a moderate degree—say 200 degrees to 300 degrees F.—provided the plant is not too small for its work. Moreover, as the demand upon it is somewhat irregular, with frequent reductions of speed, and even stoppages, the air cylinders are prevented from being overheated. Intercoolers are, of course, placed between the successive cylinders to cool the air as thoroughly as possible between stages of compression.

Examples of Compressed-Air Haulage Plants for Mines.—In illustration of the preceding notes, some of the details of a few successful installations may here be given:

‡ Notes on the theory and operation of stage compression were given by the writer in Mines and Minerals, January, 1900. It would be inappropriate here to enter into further discussion of the subject.

1. At the Empire Gold Mine, Grass Valley, Cal., in 1898, a small air locomotive was put on the 2,000-foot level, for hauling five cars, each carrying 1 ton, Fig. 3. The distance traveled in a round trip is 5,000 feet, the tank measuring about 36 inches diameter by 48 inches long, and carrying a pressure of 500 pounds per square inch. The dimensions over all are only 5 feet long by 30 inches wide by 4 feet 4 inches high, the gauge of track being 18 inches. Instead of ordinary engines, a pair of Dake rectangular piston engines are used. They are very simple and compact, with no dead centre, and have no exposed parts liable to be broken. As the haulageways of many mines are wet and muddy, there is an obvious advantage in having the moving parts of the driving engine inclosed. The locomotive was built by Edward A. Rix, of San Francisco. Another of his air motors for the same mine has two tandem tanks, on separate trucks, and is provided with a reheater, operated by a Primus kerosene burner.

2. The Peerless Colliery, Vivian, West Va., has two air locomotives built by H. K. Porter & Co., which have been running satisfactorily since 1896, Fig. 2. They measure 10 feet 5½ inches long by 5 feet 8 inches wide by 4 feet 5 inches high; have four driving wheels 23 inches in diameter, gauge 44 inches, and weigh 10,000 pounds. The main storage tank has 47 cubic feet capacity, carrying a pressure of 535 pounds; cylinders, 5 in. by 10 in.; charging time, 20 seconds. The working pressure in the auxiliary reservoir is 125 pounds. The main pipe line is 3 inches in diameter, with a total capacity of the locomotive tank. It carries a pressure of 715 pounds. The trains consist of six cars, each weighing, loaded, 8,500 pounds. Grades range from level to 2½ per cent., most of them being in favor of the load. The curves from the entries into the "rooms" are of 23 feet radius, though the locomotives are designed to work on curves as sharp as 15 feet radius; 16-pound rails are used; length of maximum round trip, 9,000 feet; maximum speed, 10 to 12 miles per hour. These locomotives make mule haulage unnecessary, as they can enter the rooms or breasts to bring out single cars for making up trains. Cost of each locomotive, $1,800.

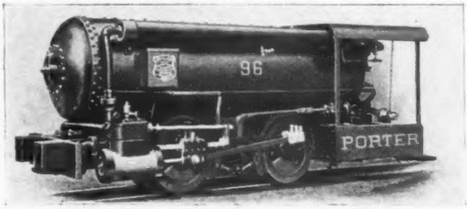


FIG. 2.—H. K. PORTER LOCOMOTIVE.

3. At the Wilson Colliery of the Delaware and Hudson Coal Company, a large air locomotive was installed in 1897 by the Dickson Manufacturing Company. It has three pairs of 26-inch connected drivers; gauge, 30 inches; wheel base, 7 feet; cylinders, 9 in. by 14 in. There are two tanks, 30 inches diameter by 18 feet 6 inches, and 15 feet 6 inches long, respectively, having a total capacity of 160 cubic feet, and carrying a pressure of 600 pounds. The 3-foot space at the end of the shorter tank allows room for the operator, and as the cylinders are placed at this end, the connections are short. The pipe line, 4,100 feet long, carries a pressure of 700 pounds, and the ratio of its capacity to that of the locomotive tanks is 7 to 1. A charging station is placed at each end of the line; time required for charging, 1 minute 25 seconds. An equalizing pipe between the tanks is provided with a valve for shutting off either tank if desired. Below the main tank is the auxiliary reservoir, in which the pressure is reduced to 125 pounds. Reheating is employed. The trains regularly hauled consist of 30 cars, each weighing, loaded, 5,850 pounds, though the locomotive has a capacity of 50 cars. The grades vary from 9 inches per 100 feet against the load, to 12 inches per 100 feet in favor of the load. Total time for the round trip of 8,200 feet, together with a switching distance of 800

feet, is 16 minutes. It is said that the haulage cost, per ton mile, is 1¼ cents.

4. In *Mines and Minerals*, September, 1899, a description was given of a Vauclain compound air locomotive, built by the Baldwin Locomotive Works, and installed at the Alaska Colliery of the Philadelphia and Reading Coal and Iron Company. A test gave the following results: An average of 26 empty cars, weighing 7,600 pounds, were hauled up an average grade of 1¼ per cent., 2,400 feet long, with 49.4 average indicated horsepower, and an air consumption of 114 cubic feet, at 200 pounds pressure. The compressor furnished this air at 750 pounds, with an expenditure of 95 horsepower, the efficiency being thus 50 per cent.

5. The Anaconda Copper Mine, Montana, is provided with air locomotives having the following dimensions: height, 58 inches; width, 58 inches; length from end to end of bumpers, 10 feet 4½ inches; four driving wheels, 23 inches in diameter; 3-foot wheel base, designed to run on curves of only 12 feet radius; gauge, 18 inches; cylinders, 5 in. by 10 in.; pressure in main tank, 550 pounds; in auxiliary tank, 125 pounds; capacity of main tank, 47 cubic feet; total weight, 10,000 pounds; charging time, 60 seconds. Length of haul, 1,200 feet (2,400 feet round trip); load six cars, weighing empty, 950 pounds, and loaded 3,450 pounds, each; track nearly level. The locomotive is built to make two round trips, or 4,800 feet, with cold air, without recharging, but it is found that by reheating with hot water, three or four round trips per charge can be made. This group of mines has now nine compressed-air locomotives.

Few records are available as to costs of haulage by compressed-air motors. In this connection, however, the reader is referred to a valuable article on the "Compressed-Air Haulage Plant at No. 6 Colliery of the Susquehanna Coal Company, Glen Lyon, Pa.," published in the Transactions American Institute Mining Engineers, Vol. 30, page 566*. Many useful data are given, including detailed comparative costs of mule and air haulage, showing for the former, 5 1-3 cents per net ton mile, as against 1.9 cents for the latter, during a period of 179 days. On the basis of 300 days' work per year, it was estimated that the cost of the compressed-air haulage would be reduced to about 1 cent per net ton mile.

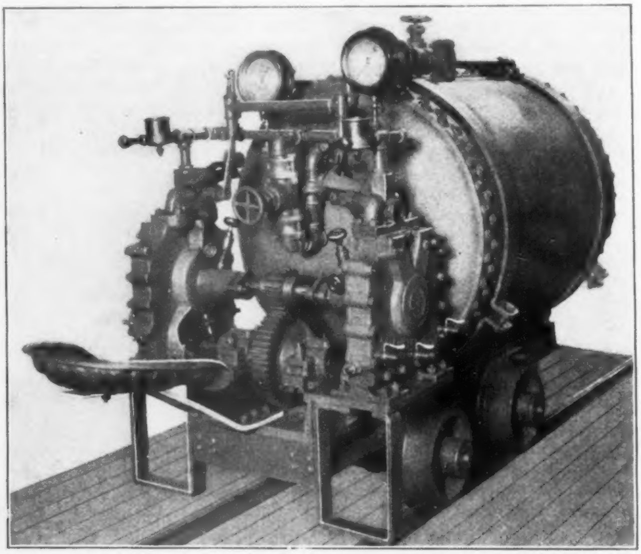


FIG. 3.—RIX COMPRESSED AIR LOCOMOTIVE.

***An illustrated description of the plant was printed in the Colliery Engineer and Metal Miner, May 1896.**

Compressed Air and Air Compressors.

BY OTTO LUHR.

Compressed air is coming into use more and more every day and in some establishments has come to be as valuable as steam or electricity. A boiler shop or a machine shop without compressed air is now-a-days considered out of date.

Compressed air is used for various purposes. It is used to drive riveting hammers, chisels, drills, and hoists. It is used for cleaning purposes, such as carpet cleaning, also for cleaning the seats in railroad cars. Cleaning by compressed air requires less than one-tenth the time, and is more efficient than the old way with a stick and brush. Compressed air is used for driving machinery at a long distance from the boiler room with much greater efficiency than could be done by direct steam. It is used for drying purposes, for pumping water or oil from wells of great depth, for cleaning boiler flues, for purifying water and many other purposes.

While compressed air is very valuable for so many business branches, it is, like all other power sources, likely to be very costly and troublesome if not understood. On the other hand, it can be made very economical if properly installed and operated.

The pipe arrangement through which the compressed air is to flow is in many cases unnecessarily complicated, and great friction is liable to be created which results in a serious loss of power. The greater the velocity of the flowing air, the greater the friction. The velocity should never exceed 20 feet per second. One elbow offers as much friction to compressed air as 20 feet of straight pipe. From this it follows that the pipe should not be taken too small, and that all unnecessary short bends should be avoided, which rules are frequently neglected.

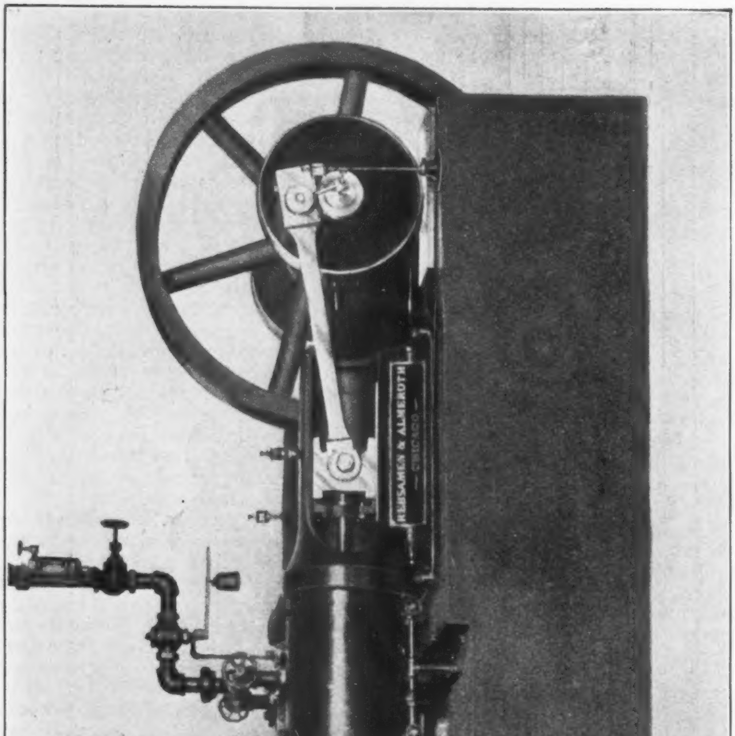
It is also a remarkable fact that so many people buy the weakest, smallest and cheapest compressors in the market, and then expect the hardest work from a machine of that kind. With a cheap machine, trouble is of a daily occurrence. Many people after some such experience, are apt to say there is nothing in compressed air, it is a failure, because they do not understand and do not care to learn.

In many plants the wrong kind of compressor is installed. There is no necessity of buying an air compressor with a separate steam cylinder when there is a power engine running at all times for other purposes. The air compressor should in this case be of the belted type, especially if the power engine is of the automatic cut-off type and able to produce a horse power per hour with thirty pounds of steam. If the compressor, however, has a separate steam cylinder of the usual slide-valve type, it will use nearly fifty pounds of steam, and in many cases more per horse power per hour. If the air, which the compressor furnishes, is not all used, a very simple releasing device can be attached to the compressor, which prevents the suction valves from closing, or the releasing device may be made to close a valve on the inlet pipe automatically if no more air is needed. A compressor so equipped furnishes no more air than is required, and consequently uses no unnecessary power with the exception of the friction of the compressor.

There is, however, a more economical and simple way to regulate the amount of air for a belted or otherwise driven compressor, if the air pressure to be carried is nearly equal to, or in excess of, the pressure of steam carried in the boiler. If nearly equal, a connection from the discharge pipe of the air compressor may be led into the steam space of the boiler with a check valve closing towards the compressor. If the air pressure to be carried, however, is in excess of the boiler pressure, then a simple reducing valve should be placed between the check valve and the air compressor. The excessive amount of air will then enter the steam boiler and become very valuable, for it produces the same power as the steam when doing work, with the advantage of lessening the condensation of the steam with which it is in contact. This has, to my knowledge, never been practiced, but I have no doubt that it will prove of great economy.

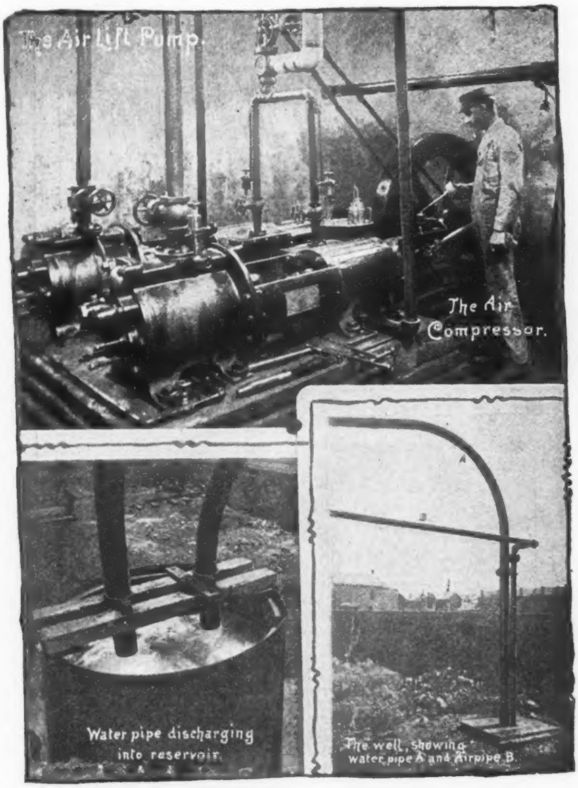
If the air is used for driving machinery I would, furthermore, make a new suggestion, which must be of great benefit, viz., that the compressed air be led through a series of coils placed in the bridging so that the hot flue gases heat the air to nearly the temperature at which they leave the boiler. This has the advantage of increasing the volume of the air considerably without cost, and prevents the freezing up of the exhaust pipe of the air driven machines, which is caused by the sudden expansion of the compressed air cooled under pressure.

It should be borne in mind that air,



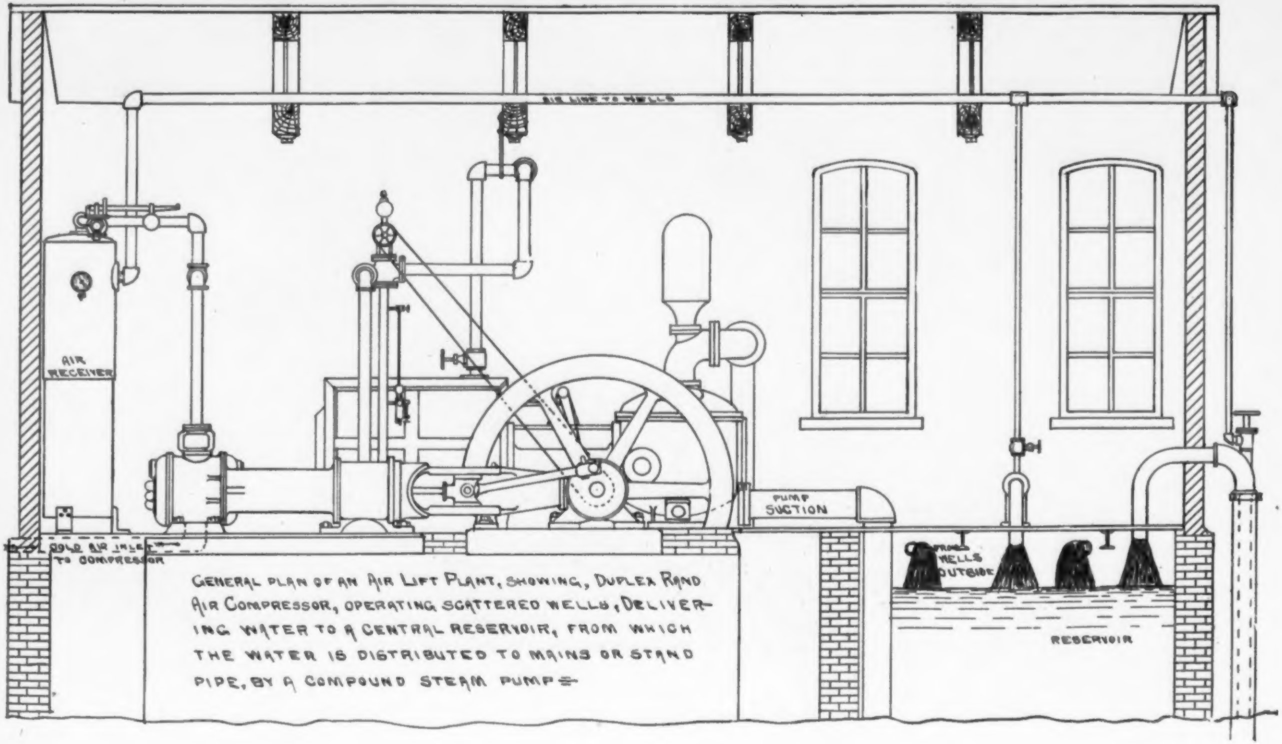
STEAM-DRIVEN DUPLEX AIR COMPRESSOR.

taken into a compressor at atmospheric pressure and ordinary temperature, gets very hot when it is compressed. The final temperature after compression is found by the following formula: $T_1 = T\left(\frac{P_1}{P}\right)^{\frac{k-1}{k}}$ in which T_1 = final temperature, T = initial



AIR COMPRESSOR FOR LIFTING WATER FROM A WELL.—SHOWING THE WELL WITH AIR AND WATER PIPE.

temperature, P_1 final pressure, P = initial pressure, and k = the ratio of specific heat of constant pressure to the specific heat of constant volume, therefore $k = \frac{0.23751}{0.16844} =$ 1.41. The pressures and temperatures are absolute. The final temperature, for instance, of 60° F. air, compressed to 100 pounds gauge pressure would be without cooling $(60 + 461) \times \left(\frac{100 + 15}{15}\right)^{0.29} = 952 - 461 = 491°$ F., which is 150 degrees hotter than the temperature of steam of 100 pounds. All air compressors are therefore equipped with a so-called water jacket to cool the cylinder walls to a certain extent. By this cooling process and by radiation the compressed air loses considerable heat and consequently volume. If this air is suddenly reduced to atmospheric pressure it must lower its own temperature far below what the initial temperature was, on account of the heat that was taken away during the time it was under pressure. The general result is that the moisture in the air freezes to ice and hence exhaust pipes of air-driven machines frequently



GENERAL PLAN OF AN AIR LIFT PLANT, SHOWING, DUPLEX RAND AIR COMPRESSOR, OPERATING SCATTERED WELLS, DELIVERING WATER TO A CENTRAL RESERVOIR, FROM WHICH THE WATER IS DISTRIBUTED TO MAINS OR STAND PIPE, BY A COMPOUND STEAM PUMP.

freeze up solid. If, therefore, air is used to drive other machinery, it is of great benefit to heat it first, provided it can be done without additional fuel, which is possible if done the way mentioned above.

It is of great importance to have the least possible clearance in air compressors. Air or any other gas cannot be pumped like a liquid, for it acts like a spring. If all, or nearly all, of the air is not discharged out of the cylinder it expands as the piston goes back, and prevents new air from coming in. Excess of clearance is, therefore, very poor economy, and reduces the capacity as well. In buying an air compressor the percentage of clearance should be specified in the contract.

The general construction of an air compressor should be of the best workmanship, and everything of heavy pattern. It should be so constructed that every part can be easily examined, and that everything can be easily reached. Air compressors should be lubricated with graphite instead of oil. The air is thus kept cleaner, and the cylinder walls lubricated much better and cheaper. Graphite is a better and cheaper lubricant than oil or grease, generally, the only difficulty being to feed it regularly, which should be done much the same way as with an oil lubricator.

The friction in a steam driven air compressor is about 10 per cent. of the total horse power required, whereas in a belt driven compressor it is frequently less than 5 per cent. The number of horse power which is necessary can easily be determined by calculation. Practical tests, however, have shown that it requires about 0.2 of a horse power to compress 1 cubic foot of free air to a gauge pressure of 100 pounds, about 0.189 H. P. for 80 pounds, and about 0.159 H. P. for 60 pounds pressure. If it is desired to get a compressor to deliver 125 cubic feet of free air and compress it to 100 pounds pressure, it would require 25 H. P. to do this. For 80 pounds it would require 23.6 H.P., and for 60 pounds of pressure about 20 H. P.

For transmitting power to a long distance, f. i., about one mile from the compressor, the maximum percentage of useful effect between the compressor and the out-turn of the motor should not be taken at more than 30 per cent. To demonstrate this, we may assume 90 per cent. efficiency of the steam engine when working the air compressor direct connected, 75 per cent. efficiency in compressing, 10 per cent. loss in transmitting one mile, and 50 per cent. efficiency of motor to be driven by air. Then we would get from 100 I. H. P. of a steam engine: $100 \times 0.90 \times 0.75 \times 0.90 \times 0.50 = 30.375$ per cent. efficiency, out of 100 steam horse power. The efficiency obtained by compressed air transmission falls about 10 per cent. short of the efficiency obtained by electrical transmission for an equal distance.

Compressed air is used extensively for lifting water or oil from deep wells. More water can be gotten out of a well with air than any other way, providing the installation is made properly. In most cases the installation is faulty somewhere, and the success consequently poor. The proper requirements for an air lifting system are very imperfectly understood by the average engineer, because there has been little published about it. The experiments that have been made in this line are also very limited, and in most cases one-sided and unreliable.

The following rules have been tested by the writer and seem to hold good:

The length of air pipe must extend down into the well three times the distance from the water level in the well to the highest point to which water is to be lifted. If, for instance, the surface of the water is 60 feet below the tank into which it is to be lifted, the air pipe should extend into the well $3 \times 60 = 180$ feet.

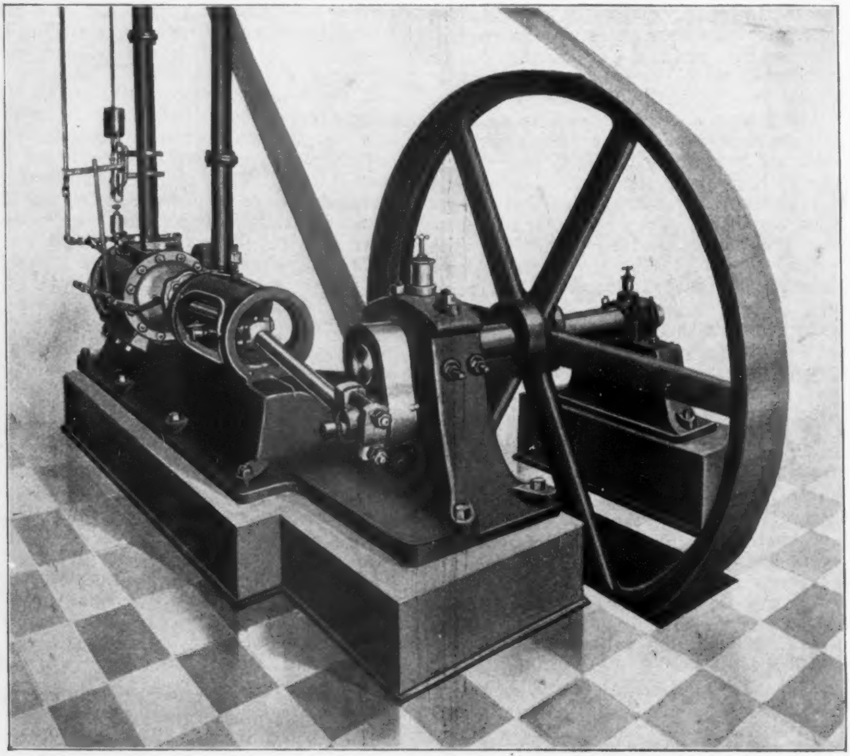
The amount of air necessary to lift a certain quantity of water a certain distance, can be determined by multiplying the quantity of water in gallons by the distance to be lifted in feet, and dividing by 125. This will give the number of cubic feet of free air required per minute. For instance, if 100 gallons of water are to be lifted 60 feet, it would require $\frac{100 \times 60}{125} =$ 48 cubic feet of free air per minute. If, however, the number of cubic feet of air is given, and it is desired to find how much water can be lifted, the number of cubic feet of free air should be multiplied by the constant 125, and the result divided by the distance the water is to be lifted. Thus, we have 100 cubic feet of free air and the water is to be lifted 60 feet; how many gallons can we get? In this case we can get $\frac{100 \times 125}{60} = 208$ gallons per minute.

One point seems to have been hitherto neglected. As far as the writer knows, it

has never been determined what is the most efficient velocity of the water, and experiments in this line are wanted. Whenever this is known, we can easily determine the proper size of water and air pipe we should have in the well. In a great many cases the water pipe leading down the well is too narrow, and the amount of water obtained, therefore, too small regardless of the amount of air pressure applied. It is evident that only a limited supply of water mixed with air can run through a pipe of a given size.

As the air contains plenty of moisture when in its natural state, this moisture comes down like rain in the air receiver when the air gets compressed to a higher pressure. It is, therefore, advisable to place a regular steam trap below and connect it to the bottom of the tank, when the trap will discharge all the water without losing any compressed air. This device is new, but works like a charm, and keeps the air almost perfectly dry.

The most economical way to compress air is to do it in stages, that is, to use two or more cylinders, compressing it to a low pressure in the first, then passing it through a cooler to cool it to nearly the temperature of the cooling water, and then further compressing it to a high pressure, cooling it again and compressing it again, and so on according to the pressure required, the two-stage or compound compressor being used for pressures between 60 and 300 pounds, the three-stage or



KROESCHELL AIR COMPRESSOR.—DRIVEN BY BELT, FROM A LINE SHAFT.

triple compressor between 300 and 1,000 pounds, and so on. To compress 100 cubic feet of free air to 75 pounds would require about 16 H. P. with a single cylinder, and 13.75 H. P. with a compound cylinder. But if the air is to be compressed to 500 pounds pressure there would be required 40 H. P. with a single, and 30 H. P. with compound cylinder, constituting a saving of 14 per cent. for 75 pounds of pressure and 25 per cent. for 500 pounds of pressure by the compound cylinder. It is thus evident that compounding is very economical for higher pressures.

The colder the air is to start with, the better. It should be always taken from as cold a place as possible For every 5° that the intake air is colder than the air in the engine room, a saving of 1 per cent. is effected in running the machine. The capacity is also increased. If the air in a brewery is taken from the cellars at a temperature of 35° F., instead of from the engine room in the summer time, where the temperature may be 85° F.. a saving of $(85-35) \div 5 = 10$ per cent. is effected by doing so.

At greater altitudes the atmospheric air is more rarified, representing less pressure per square inch, as shown by the following table:

At sea level	14.7 lbs. per sq. in.
At ¼ m. above sea level	14.2 lbs. per sq. in.
At ½ m. above sea level	13.33 lbs. per sq. in.
At ¾ m. above sea level	12.66 lbs. per sq. in.
At 1 m. above sea level	12.02 lbs. per sq. in.
At 1¼ m. above sea level	11.42 lbs. per sq. in.
At 1½ m. above sea level	10.88 lbs. per sq. in.
At 2 m. above sea level	9.88 lbs. per sq. in.

This table shows an approximate reduction of ½ lb. per square inch for every 1,000 feet of ascent. The losses at great altitudes, for which allowance should be made when buying an air compressor, are about 7 per cent. for ¼ mile, and 34 per cent. at two miles or the increase is about 4 per cent, for ⅜ mile.—*National Engineer.*

Comparison of Compressed Air with Steam and Electricity at Rossland, B. C.*

Compressed air has become so generally used in connection with mining operations, and so well recognized as the most useful and economical power, with its unlimited range of uses, and special adaptability to underground work, that an introductory to this paper on the subject would be superfluous to mining engineers.

The comparative economy of prime movers for air compressing engines is, however, of great interest to all, and a subject on which any engineer can read with interest. This is particularly the case with engineers practicing in British Columbia, where a large number of the mining problems include the extraction and reduction of large bodies of low-grade ores and the consequent necessity for a thorough study of economical methods for mechanical handling.

The general mobility of compressed air as a power allows a wide range of generators, or prime movers, but we can, in nearly all cases, rely upon having to adopt primarily, one of two sources of power, viz., water or heat.

Water, the first of these, can, as we know, be used in many ways, each terminating finally at the mine, as compressed air ready for service. The initial water power may come from one or more sources situate either at the mines or many miles distant, and can be used either as a directly connected unit of power for the compression of air, or as a prime mover for some intermediary power.

British Columbia has been fortunately blessed with magnificent water power, more particularly in the Kootenays. In many cases these water powers are situated close to the mines; in others, as at Rossland, they are several miles away.

Distances over which power can be economically transmitted by electricity are yearly becoming greater until it seems that distance is no longer an obstacle, and it has become simply a question of capital investment to successfully transmit the power generated by water almost any distance.

Heat, the second great source of power for the generation of compressed air, has been successfully used as steam for many years, even in places which seemed to be utterly inaccessible either for the erection of the necessary machinery, or the securing of fuel after the machinery had been installed and made ready for operation. So accustomed have we become to surmounting difficulties of this kind, that we are apt to look with suspicion upon any suggestion to utilize distant water powers, preferring to resort to steam as being the power we best understand, and one which has been successfully installed

*Paper read at the Nelson meeting of The Canadian Mining Institute, 10th September, 1902.

and economically operated under very adverse circumstances.

British Columbia has been abundantly provided with fuel, in fact, we can say the supply of coal is practically unlimited. Enterprising capitalists, year after year, extend railways between the coal fields and the consumers, so that no producing or promising mining district has long to wait for an unlimited supply of this fuel. The mines at Rossland are exceptionally favored in this respect, all the leading mines having access to two lines of railways, and, through them, the coal fields of both British Columbia and the State of Washington.

Rossland is also favored by having the immense water power at Bonnington Falls, less than 40 miles distant, immediately available. The enterprise of Sir Charles Ross and associates in the West Kootenay Power and Light Co. have rendered this available for any service at each mine, as a competitor of the steam power, which mine managers would otherwise be compelled to adopt.

The question of the selection of power supply to be made by mine managers at Rossland is almost entirely removed from chance, and may be based on ascertained facts. Railways being at hand for the transportation of any kind of machinery, reasonably cheap fuel in quantities required is assured, and electric power for any size machinery or service is available. Therefore the problem simply resolves itself into *"Which of these powers will give the best service in operating the machinery used in connection with mining operations?"*

The same privilege applies to nearly every other mining district in Southern British Columbia; therefore, the writer feels that the results obtained in the air compressing plants at Rossland will be of special interest to the members of the British Columbia section of the Canadian Mining Institute, and mining engineers.

The steam and electric plants described further on were modelled on the design and erected under the personal supervision of Mr. Bernard Macdonald, then general manager of the Le Roi and Nickel Plate mines, assisted by the writer. The steam plant was erected for the Le Roi Mining Company, Limited, and consists of the following, viz.:

Boiler Plants.—Two 250 horse-power Heine safety water tube boilers, arranged to burn coal as fuel. These were intended to generate steam to run the air compressors, and were set so as to work, if desirable, in connection with the nine 125 horsepower steel shell return tubular boilers, designed to operate the hoisting and surface plants. These boilers are arranged to be interchangeable to either service. A general description of this plant will be found in volume V., page 309, of the Journal of the Canadian Mining Institute.

During the test, the water-tube boilers were used at a gauge pressure of 150 pounds per square inch, using Crows Nest coal as fuel, which cost, laid down in front of the boilers, $5.55 per ton of 2,000 pounds.

Air Compressing Plant.—The steam driven plant consisted of two compound condensing Corliss valve engines, direct connected to two stage air cylinders, equipped with intermediate cooling devices, each machine having a rated capacity of 4000 cubic feet of free air per minute, or a combined capacity of 8000 cubic feet of free air per minute at sea level.

A more detailed description of these engines would be as follows:

	No. 1 Engine. INCHES.	No. 2 Engine. INCHES.
Diameter high pressure steam cylinder	22	22
Diameter low pressure steam cylinder	36	36
Diameter high pressure air cylinder	22	22
Diameter low pressure air cylinder	36	38
Length of stroke	48	48

Intercoolers, horizontal multitubular type; condensors, independent jet.

The Electrically Driven Air Compressing Plant.—This plant was erected by the Rossland Great Western Mines, Limited, and was originally intended to be operated in connection with the steam plant previously described, the intention being to supply power from a central station to four mines, owned by different companies. This arrangement would have given each mine power at the lowest possible cost, and have ensured continuous operations by reason of the compressing plant being arranged in separate units. Each company would pay its share of operation, maintenance, of plant, *pro rata* to its consumption of air.

When it was found necessary to erect the third unit to the compressing plant,

unforseen difficulties presented themselves in the shape of shortage of water for condensing and cooling purposes. On examination, it was found that a satisfactory supply could not be secured without heavy capital expenditures for erection of flumes, etc., to convey the water to where it was required for use.

It was, however, found that a supply of water, barely sufficient for the intercoolers and waterjackets, was available about three-fourths of a mile distant from the steam plant. This supply was so located that it must either be pumped or else the plant located at this distance away from the main steam plant. By conserving this water supply, cooling, and reusing, it was decided a sufficient supply of water for the air cylinder jackets, and intercoolers could be secured.

The results obtained from the steam plant had proven so satisfactory that it was considered questionable if any electric plant could be installed that could successfully compete with steam, even when running non-condensing, unless very favorable rates for power could be secured. After negotiations with the Power Company, it was decided to erect an electrically driven plant, a short description of which is as follows:

Electrical Equipment.—Three phase, S.K.C., synchronous motor, designed for 2200 volts, with a rated capacity of 660 kilo watts, equivalent to about 825 horse-power. The motor is provided with a separate starting motor, mounted on the main frame, exciter and Italian marble switch-board, on which all operating switches and instruments are mounted.

There is a 54 inch Frisbee clutch set intermediate between the driving pulley and the motor. The motor is of a four bearing type, fitted with self-aligning and self-oiling sleeves. The entire machine is mounted upon a solid cast iron base set upon massive concrete foundations. The driving pulley is 60 inches in diameter, grooved for 22 1½ in. ropes, and runs at 270 revolutions per minute.

The three compressors were built by the Canadian Rand Drill Company, of Sherbrooke, Quebec, and are especially designed for constant service.

The electrical equipment is also entirely of Canadian manufacture, the entire apparatus being manufactured by the Royal Electric Company, of Montreal, who are the Canadian manufacturers of the S.K.C. apparatus.

All tests were conducted under the personal supervision of the writer, and extreme care was taken to arrive at actual facts. Indicator diagrams were taken off both the steam and air cylinders every half-hour, and the results tabulated. Coal consumed was weighed, and all other supplies, such as waste, oil, etc., charged as used.

Readings were also taken and recorded by means of a delicately adjusted kilo watt metre, connected to the primary mains, of the amount of electric power used. The test extended over a period of thirty days, without interruption, both plants being run under exactly similar conditions as to air pressure.

Each of the plants tested being modern and representative of their respective types, gave an opportunity for a comparative test that rarely falls to the lot of an individual engineer under such favorable conditions, as to work being performed, and for this reason is the more valuable as data for basing calculations as to problems of power.

The average results of the thirty days' test is recorded in Tables I, II, III, IV, and V following:—

TABLE I.

Work Performed by Steam Plant.

Average indicated horse-power at steam cylinders of the combined machines	730 h.p.
Free air compressed per minute from atmospheric pressure to 95 lbs. per square inch.....	5432 cu.ft.
Free air compressed per hour..	325,920 cu.ft.
Average horse-power required at steam cylinders to compress 100 cubic feet of air per minute, to gauge pressure......	13.4 h.p.
Pounds of coal consumed during test	1,038,000 lbs.
Pounds of coal consumed per day of 24 hours............	36,400 lbs.
Average pounds of coal consumed per horse-power per hour during test...........	1.9 lbs.

TABLE II.

Work Performed by Electric Plant.

Average h.p. registered at switch-board	540 h.p.
Free air compressed per minute from atmospheric pressure to 95 pounds gauge pressure...	3,319 cu ft.
Free air compressed per hour..	199,140 "
Average horse-power required at motor to compress 100 cubic feet of free air per minute to 95 lbs. gauge pressure......	16.3 h.p.

TABLE III.

Cost of Operating Steam Plant.

Total cost of fuel consumed during test	$2,880.45	
Total cost of wages for employes	710.00	
Total cost of oil, waste, etc.	147.30	
Total cost for 30 days, exclusive of maintenance and depreciation		$3,737.75
Cost per horse-power per month for fuel	3.96	
Cost per horse-power per month for oil, etc.	0.20	
Cost per horse-power per month for wages	0.97	
		$5.15
Cost per horse-power per annum		$61.56
Cost for each 100,000 cubic feet of free air compressed		1.56
Cost per drill shift		1.25

Note.—80,000 cubic feet taken as the average consumption per shift of one 3¼ in. drill.

TABLE IV.

Cost of Operating Electric Plant.

Cost of current for 30 days	$1,744.26	
Cost of employees' wages	270.00	
Cost of oils, waste, etc.	73.00	
Total cost for 30 days, exclusive of maintenance and depreciation		$2,087.86
Average cost per horse-power per month		3 87
Average cost per horse-power per annum		46.44
Cost for each 100,000 cubic feet of air compressed		1.46
Cost per drill shift		1.17

Note.—80,000 cubic feet taken as the average consumption per shift of one 3¼ in. drill.

TABLE V.

Showing Comparative Results between the Two Types of Compressors, based on each 100,000 cubic feet of air compressed from Atmospheric Pressure to 95 Pounds Receiver Pressure.

Cost for each 100,000 cubic feet of free air compressed by steam plant (see Table III)	$1.56
Cost for each 100,000 cubic feet of free air compressed by electric plant (see Table IV)	1.46
Result, saving by electricity over steam	6.4 per cent.

The saving shown in Table V would be affected adversely if the electric plant was operated singly and the entire air compressed was not used. For the reason that electrically driven compressors must be operated at constant speed, and loss of air at safety valve would be considerably increased over the same loss at steam plant, which could be run at the speed required to compress the amount of air actually required. This loss would, however, be slightly off-set by the increased cost per horsepower by working the steam compressors on underload.

I wish to draw special attention to the noteworthy results obtained from the system of intercooling used on the compressors tested.

In Table I it is shown that the steam plant required 13.4 horsepower to compress 100 cubic feet of air to 95 pounds gauge pressure per minute. The best power factor recorded that has come under the writer's notice, for doing the same amount of work by a two stage compressor, is 14.5 horse power, which shows a saving of 8 per cent. resulting from the use of specially designed intercoolers, for which the manufacturers are entitled to receive the credit.

How this result is obtained can be best understood by reproducing the average of a number of tests made on the efficiency of the intercooler during the progress of the power test. The results of these tests are shown in Table VI.

TABLE VI.

Temperature of cooling water at inlet of intercooler	42 deg. F.
Temperature of cooling water at outlet of intercooler	50 deg. F.
Rise in temperature of cooling water while passing through intercooler	8 deg. F.
Temperature of air at outlet of low pressure cylinder and before passing through intercooler	196 deg. F.
Temperature of air at inlet of high pressure cylinder after passing through intercooler	54 deg. F.
Reduction in temperature of air after passing through intercooler	142 deg. F.

In conclusion, permit me to state that this paper has not been prepared with the idea of recording the performance of these two plants, except, in so far as comparisons can be drawn between the relative efficiency of the two systems, so that engineers, knowing local conditions, can have some record of actual performance before them.—Wm. Thompson, for *Canadian Mining Review.*

The Corrington Air Brake.

The Corrington air brake was, it will be remembered, mentioned in some of the discussions at the June conventions at Saratoga. Some time ago this system was tested on one of the principal railways and the result led to the formation of a company in which a number of railway officials are interested. This was done after the patent question had been gone into carefully and was believed to be safe. The Corrington Air Brake Co., having now secured a plant in which it is installing machinery for preliminary operations, our readers will be interested in learning what they have to offer and the claims which are made for their system. The following is its own statement on these points:

"The Corrington system utilizes all of the auxiliary reservoirs, brake cylinders, cut-off cocks, air pumps and governors, exactly the same style and manner as now in use. The triple valve, engineer's valve and high speed pressure valve of the Corrington system are interchangeable as to position with the Westinghouse system, as they can be placed in identically the same position respectively as they now occupy on the locomotives and cars equipped with the Westinghouse system. Consequently, the new results offered by the Corrington system may be obtained by the railways on all new equipment without increased cost, and all old equipment can be altered to secure the same results at the slight cost necessary to change the triple valves on the cars, and if desired, the engineer's brake valve on the locomotive.

The new brake gives increased control both in setting and releasing, and overcomes to a much greater extent than do the brakes hitherto in use, the difficulties presented by dirty or defective triple valves or irregularity of brake cylinder piston travel. This is accomplished by a device automatically applying full train line pressure to release the brakes, when required. Overcoming the irregularity of release due to the causes stated above, is of the greatest importance, reducing, as it does, the danger and expense incident to breaking trains in two, especially at slow speeds, where the failure to release one or more brakes toward the rear end of the train is now the too frequent cause of the parting of freight trains.

Another and more important feature is that the auxiliary reservoir may be recharged without releasing the brakes, thus dispensing with the retaining valve, the insufficiency of which to give the desired control is especially evident in the case of loaded gondola cars of high capacity. On roads with long, steep grades this advantage is self-evident, although rather costly experience, even on roads without such grades, has demonstrated that this is a consummation greatly to be desired. The control of the train is thus placed entirely in the hands of the engineer, avoiding the necessity of the train crew acting independently, and too often disastrously. One road has gone so far as to discontinue the use of the air brake on all freight trains when descending a heavy grade, and as a consequence is handling down this grade its heavy freight traffic by hand brakes, at a slow speed. The ability to keep air brakes continuously applied, and maintain auxiliary reservoir pressure with which to stop when necessary, means to this and many other roads speed and safety in descending grades.

As corollaries to the recharge without release feature of the new apparatus: (1) The brakes may be set and released any number of times without the possibility of the engineer finding no air in the auxiliary reservoir to meet an emergency. (2) With the engineer's brake valve handle in the recharge position sufficient pressure to offset train line leaks is thrown into the train line while the brakes remain applied, thus preventing the brakes applying harder than intended, which is at present of frequent occurrence, owing to the failure of the present systems to supply air to offset such leaks when the engineer's valve has been placed in the "lap" position. (3) With the return of the engineer's brake valve handle to the recharge position, after each reduction of train line pressure, the air pump starts immediately and main reservoir pressure is regained simultaneously with the recharge of the auxiliaries. The importance of this much more continuous use of the pump, instead of the spasmodic and necessarily violent calls made upon it by the apparatus in use at present, can hardly be overstated.

As the air pump is used more evenly and continuously, it requires less capacity in the pump and main reservoir. Consequently, it will not be necessary to in-

crease the size of the pump and main reservoir as is now being done to accommodate the heavier train loads, and owing to the avoidance of spasmodic action of the pump by the adoption of the Corrington system, the cost of maintenance of the pump will be considerably reduced.

Another important advantage of the Corrington engineer's valve and high speed and high pressure control apparatus is its simplicity. In order to provide for the two feed valves necessary for all high speed or high pressure control apparatus, the low or normal pressure feed valve must, in the present system, be cut out when the high pressure feed valve is to be used. In the Corrington system both feed valves are attached directly to the engineer's valve, and are thrown in or out of action by the brake handle alone, thus dispensing with detached feed valves and with the cut-out or reversing cock and connecting piping, simplifying the operation of changing from low to high pressure. This result is attained by a novel rearrangement of ports and cavities in the rotary valve and valve seat without increasing the size of the engineer's valve. The entire high speed and high pressure control apparatus of the Corrington system is much simpler than the apparatus in present use, consisting only of about one-half the number of parts.

The advantages of the results to be secured in the Corrington system involves no transition period. The triple valve is constructed in two parts, so designed as to make it practicable to cut out the recharge release part in a similar manner to the operation of the present retaining valve. The object of this is apparent. It is to be expected that the extra switching necessary to get cars equipped with the Corrington recharge release device next to the engine will be as willingly performed as was the case before the present nearly universal use of the Westinghouse brakes was attained. If, however, owing to circumstances, it is inconvenient to place the car so equipped next to the engine and it should be left in the train among its predecessors, then if it is desired the recharge feature may be cut out as conveniently as the retaining valve is now operated. The Corrington triple then performs its functions in a similar manner to its neighbors with the advantage obtained from the Corrington release mechanism, insuring the release of the brakes on that car when normal train line pressure is attained should the release not have been previously effected. With the engine and tender alone equipped with the Corrington recharge release mechanism in the place of the present engineer's brake valve and triple valve, the advantages in train control are apparent. The addition of each car at the head end of the train is so much more gained in train control with no disadvantage whatever as far as the operation of the other brakes on the train is concerned."—*Railway and Engineering Review.*

Reheating Air for a Compressed Air Mine Hoist Driven by Electric Power.*

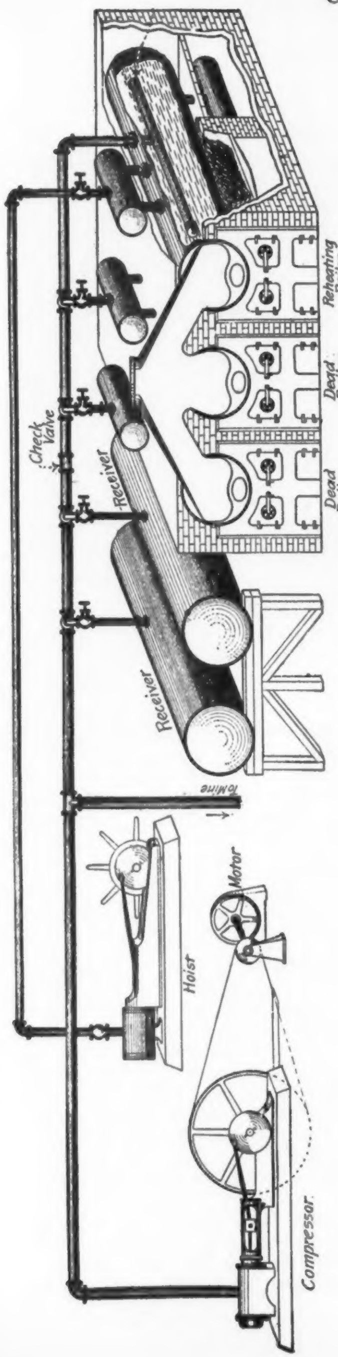
BY C. O. POOLE,‡ M. AM. INST. ELEC. E.

The mine superintendent takes kindly to the electric motor for all purposes except for hoisting, and to my mind his exception is well taken, for until a simple, better and more reliable electrical hoist is developed, I will hesitate to recommend them to a customer. In my opinion, compressed air is going to be universally used for hoisting purposes, where cheap electric power is obtainable and when an air compressor is required for other purposes in the mine. In the ordinary use of a compressor at a mine, it is not used to its rated capacity more than 40 per cent. of the time. If, then, receiver capacity be available to store the air at times of light demand upon the compressor by the drills, and thus enable the compressor to be operated at full load all the time, the motor and compressor would be run at their highest efficiency, and sufficient air could be stored to operate the hoist under ordinary conditions, and quite efficiently, too, by reheating the air. It is not generally known that a pound of coal used for reheating air will produce a horse-power hour, while it requires from 4 to 5 lbs. of coal to give the same result with steam; but such is the case if the air be used in an engine fitted for the purpose.

But, for the sake of argument, let us suppose that we use the air without reheating, and assume that air and steam are equal as far as expansive effects are

*Extract from a paper read at the Sixth Annual Convention of the Pacific Coast Electric Transmission Association.

‡Manager Standard Electric Co., San Francisco, Cal.



ARRANGEMENT OF BOILER PLANT FOR REHEATING COMPRESSED AIR.

concerned; then, if electric power costs $6.50 per H. P. per month, and the compressor has an efficiency of 60 per cent., the cost for air delivered to the engine will be $10.83, and by using a small amount of fuel for reheating, these results can be far exceeded.

At the Lightner Mine, Calaveras county, Cal., electric power has been used exclusively for several years. A 150 H. P. motor drives a two-stage compressor 13x21x22 in. stroke, and running at 75 revolutions per minute. The saw-mill, a pump and a blower are also driven by the same motor. The relief pipe from the air receivers is connected to the steam boilers, two of which act as additional receivers, and another one of them being used as a reheater. About one cord of wood is burned per day in reheating. There is operated a 60-stamp mill, which is driven by a 100 H. P. induction motor; a 20 H. P. motor drives the rock crusher, and a 5 H. P. motor is used for operating a telpherage system for carrying sulphurets to the chlorination works. All the hoisting is done with compressed air, as is also the lifting of all the water, which is taken from the 600-foot level. In addition to this work, seven 3¼-in. drills are supplied with air from the same compressor. The total power bill for January, 1902, was $1,457.50, including the cost of the wood used for reheating purposes, which makes the power cost per ton of ore milled to be 21 cents, including all power charges.

The engraving herewith shows the arrangement of compressor and receivers that have given such excellent service at the Lightner Mine. It will be observed that a check valve is placed in the relief pipe, between the mine receivers and the boilers. Any excess of air flows through check valve into the boilers, and the air that is used for hoisting is all taken from the reheating boiler; the air passing into this boiler enters through a perforated pipe, which is submerged about 6 ins. below the surface of the hot water. This arrangement permits all of the air to come in contact with the hot water, and is very rapidly heated. As air is drawn from this boiler by the regular steam pipe, and the pressure is lowered, air from the other boilers and receivers immediately flows in, thus utilizing all of the receiver capacity for the hoist during moments of heavy demand. Between

skips, the compressor has time to recharge the receivers.

With an installation of this kind properly proportioned as regards motor, compressor and receiver capacities, to my mind, it leaves little to be desired from the point of economy, convenience and reliability.

At the present time there are several large compressed air plants in course of erection in Amador county, all of which are to be electrically driven, and reheated air is to be used for hoisting.—*Engineering News.*

A New Clam Shell Dredge Operated by Compressed Air.

Interest is taken by dredging contractors, engineers, and in army and navy circles in the recent inventions of Mr. E. Chaquette, of New Rochelle, N. Y., covering an application of compressed air by a new and ingenious method to close and open automatically a clam shell for subaqueous excavation.

As shown by Fig. 1 of the accompanying cut, a hemispherical shell consisting of two hinged halves is mounted upon a suitable frame. A valveless cylinder is attached to the outer side of one of these halves and its piston to the outer side of the other, with mechanism by which the admission of air to one side of the piston opens and to the other side closes the clam. The clam is supported by three cables preferably; the outer two for counterbalances being attached to the extremes of the cross bar of the clam frame. The middle or hoisting cable is attached to a slide which passes through the center of the cross bar, and is surrounded by a coiled spring, which automatically controls the admission of compressed air to close and open the clam. This air is fed through a journal box to the drum pulley carrying the air pipe, which is mounted on the same shaft with the center or hoisting pulley; or on an independent drum with gear which meshes with the hoisting pulley, so that there is a simultaneous feeding and rewinding of the air pipe, and the counterbalance and hoisting cables, effected by the same motor.

Upon the clam is mounted a guide rod or rods to which a cylinder and its operating piston is suspended by arms

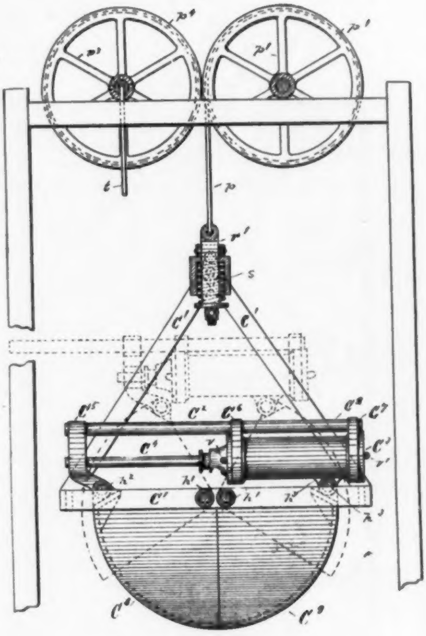


FIG. 1.

which are adapted to slide along such rod from an extended to a contracted position, the cylinder rising and sliding on the guide rod as the clam is opened, and vice versa. In cut 2 dotted lines show the cylinder elevated and the clam open. The cylinder is provided with ports at each end, and with suitable exhaust ports.

Hence, as the guide rod holds the cylinder and itself parallel, the in-stroke of the piston raises the piston, guide rod and cylinder bodily, and at the same time draws upward and together the two upper outer sides of the clam and apart its lower or cutting edges. When the arm traveling on the guide rod engages the head of the cylinder it is at its highest point, and the clam is wide open. When the air is shifted to the other side of the piston the reverse action takes place and the clam is closed; and so held by the pressure until the air is shifted to open and empty the clam.

A three-way valve diverts air from its pipe to either end of the cylinder. This is so adjusted that as the clam settles in the material open, the slackening of the

center or hoisting cable turns the valve and admits the air under pressure against the piston, forcing the piston rod out,

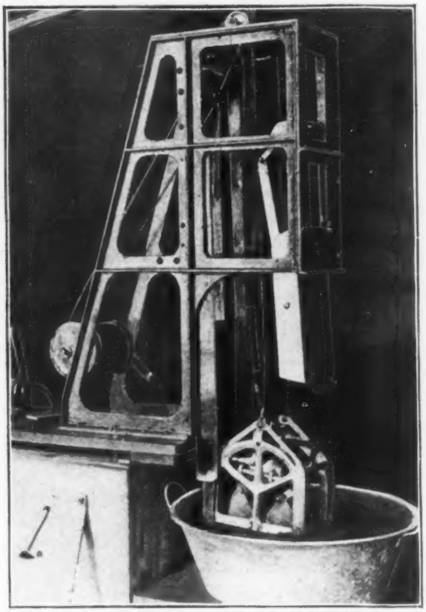


FIG. 2.

causing the guide rod and cylinder to settle, thus closing the clam which cuts into the material, and is then filled and ready to be lifted by its hoisting cable.

At an elevation suitable for dumping a tappet engages the valve and diverts air to the reverse side of the piston, causing it to make its in-stroke, thereby lifting the guide rod and cylinder and opening the clam.

For the operation of this compressed air clam, a float or barge of any desired width is provided, across the front of which is built a projecting frame-work (Figs. 2, 3 and 4) for supporting dredge carriages adapted to move automatically for a distance even greater than the beam of the boat. On this framing are travel carriages supporting two or more independent clams, which rise and fall vertically.

As the clam descends a collapsible apron or trough (Figs. 2 and 4) drops with it, follows it up when the clam is raised, and receives the discharged material. This trough may be adjusted to discharge either side, forward, or into diverging troughs fitted with agitating chains to carry to scows alongside, or converging troughs to carry to the center of the float; or the trough will discharge aft onto a movable apron, which will carry material astern of the scow, as will be seen by reference to Fig. 3 and also Figs. 2 and 4, which show this trough in both positions.

Provision is made to attach cables to

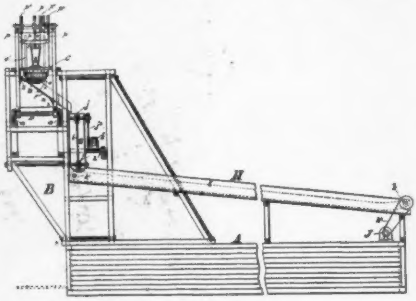


FIG. 3.

the extremes of the frame of the clam, to lead to the top of the dredge carriage and over sheaves aft, to support counterbalancing weights adjusted to the character of the excavation; so that power is required to lift only such proportion of the weight of the clam as may be necessary to give it penetration. These cables take the place of poles formerly used to hold the clam steady and prevent it toppling over on hard bottom, and permit work at great depths.

Figs. 2 and 4 show a working model of the clam and dredge carriage. In Fig. 2 the clam is lowered onto wet packed sand, its top contracted and cylinder elevated, with the beveled cutting edges of the clam open and ready to bury themselves when air is applied to the left end of the cylinder, which will then settle down as the outer circumferences of the clam are forced apart and its cutting edges together.

The trough has dropped by gravity, and is ready to follow the clam up when its frame engages the arm projecting into the upper part of the framework, which arm is vertical when the trough is raised.

In Fig. 4 the clam is hoisted and open, having discharged its load onto the inclined trough.

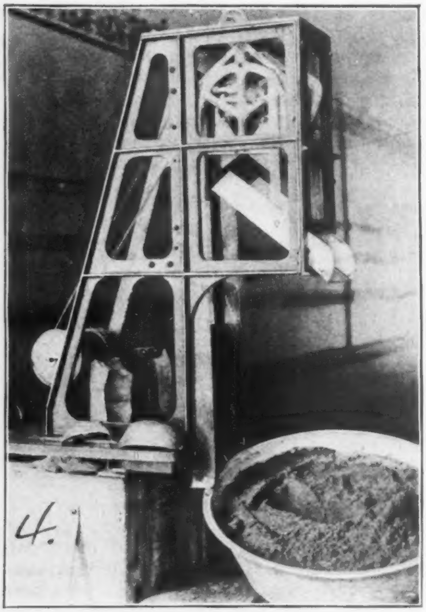


FIG. 4.

Arrangements are well advanced for constructing a dredge under these patents, and its practical operation is awaited with great interest. The first claim for the clamshell is its admitted efficiency in bringing up a maximum load every trip in hard material, due to its closing and burying itself deeply by the automatic application of a controllable power, independent of the lifting power.

If this clam is fitted to the present type of dredge with swinging boom, there will be a substantial saving in the time required to fill, with the advantage of a full load in clay or hard pan; and with no dripping or leakage in soft material.

By the use of the projecting framework it is clamed that two dredges will be combined in one, with consequent economy in initial cost and maintenance, wages, etc. There will be greater uniformity of excavation. Should one clam get out of order, work could continue at reduced capacity pending repairs.

With the boom about 30 per cent. of the time of a trip is required to swing the boom, and from 15 to 30 per cent. in filling. Consequently, by this new method for excavating and elevating material, it is claimed trips would be made from 25 to 30 per cent. quicker than at present, which would conservatively make the capacity of a Chaquette dredge equipped with two three-yard compressed air clams, 500 cubic yards per hour for a machine costing no more than a present type dredge with one three-yard clam, the operating expenses of each being about the same.

Some time ago an engineering project in New York harbor was abandoned because eminent engineers were unable to find a dredge which would satisfactorily excavate at the depth of 150 feet. We understand that it was frankly stated that had this compressed air clam been on the market at the time it would have been favorably considered.—C. E. DAVENPORT.

Gas Producer Working with Compressed Air.

The Gardie gas-producer, shown by the accompanying elevation (Fig. 1) and vertical section (Fig. 2) is distinguished from all other machines of this sort by the circumstance that it is supplied with compressed air, which may be produced by a compressor, an air-pump or a blowing engine, and the gas produced has the same pressure as the compressed air, and may be used directly for motive power, as well as for firing furnaces, while the use of compressed air permits of obtaining continuously a large volume of gas with a producer of small size. Inasmuch as the gas is generated as required, without any necessity for storage, a gasometer is unnecessary. The adoption of high pressures insures a complete gasification of the fuel employed, and the gas obtained is free from the usual impurities, tar and ammoniacal liquor, so that suppression of scrubbers and condensers are not needed.

The producer case, a (Fig. 2), is made of steel plate, in three parts, connected by the angle-iron rings, bb, bolted together, while the dished bottom, d, is riveted to the cylindrical portion. The fire-clay lin-

ing, e, leaves a space in the middle for receiving the fuel, this space being cylindrical generally, but assuming a conical form below for ensuring a regular distribution, through the mass of incandescent fuel, of the compressed air that supports combustion. On the dished top there is a short pipe, f, carrying a cast-iron plug-valve, g, (worked by the lever H I H), through which the fuel is admitted to the producer in accordance with requirements, falling from the spherical receptacle, h, which is closed by the screw cover, B, and contains a charge sufficient for two hours' working. The inverted funnel, i, is calculated so that the height of the fuel shall remain constant inside the producer. Apertures, j j, left in the fire-clay lining, permit of removing cinders or clinker, these apertures being closed by the screw doors, AA. Along the center line of the producer, and having its top flush with the bottom of these evacuation apertures, is a vertical steel tuyere, k, which fits on to and above the pipe, l, that brings up the air supporting combustion.

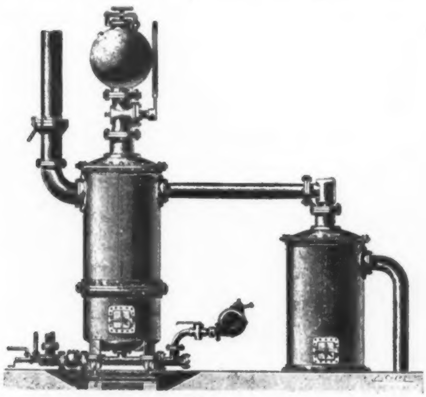


FIG. 1.

The compressed air, led to the distributing receiver, S, fitted with the pressure-gauge, K, and safety valve, L, makes its way by the pipe, E, fitted with the stop-cock, G, into the bottom of the producer, mingled with water spray delivered by the injector, p; and a check-valve, q, at the entrance to the producer, prevents any return of the gas generated into the air receiver, the quantity of water being regulated by turning the handle. The gas issuing from the producer is led by the pipe, r, to a dry scrubber, s, for being freed from its dust, and it goes directly from this latter to the motor or furnace, as the case may be, where it is to be utilized.

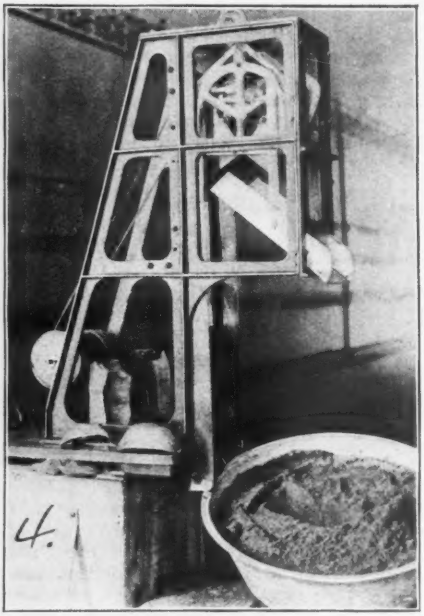
The chimney, T, is only required for firing up the producer, and when, on the latter being started, the gas burns regularly at the chimney entrance, all the apertures are to be closed and compressed air admitted, when gas will be produced continuously in proportion to the volume of air. Owing to the water spray, the clinker adheres so little to the producer sides that it can be easily removed; and, as the air pressure is constant, the volume and composition of the gas do not vary, so that this producer is especially suited for providing gas to be used directly in motors. It is well adapted for large gas engines, and the floor space occupied by a producer with its accessories for a 500-horse motor does not exceed 10 sq. m. (11 sq. yds.).

Any non-bituminous coal that does not cake and contains less than 8 per cent. of volatile matter, though it may contain as much as 20 per cent. of ash, will serve for this producer; the fuel should be pea or nut size. As the whole of the fuel is turned into gas, the proportion of carbonic acid never exceeds 2 per cent., so that the calorific power is considerable, thus affording the high temperatures required in iron and glass furnaces. This arrangement is also economical, because the fuel is consumed exactly in proportion to requirements, and the production of gas ceases with shutting off the compressed air supply, so that the expenditure of gas can be strictly limited to the work it has to perform.

The use of combustible gases under pressure permits of a slow or quick working of the furnace, as may be required; and the use of compressed air as the supporter of combustion permits of regulating this working, while also affording a reducing, neutral or oxidizing flame, as may be required. A characteristic of the use of gas under pressure is combustion without smoke, an invaluable feature for large towns.

The chemical composition of the gas, on which the calorific power depends, is variable at will between the two limits corresponding with (1) air gas and (2) mixed gas with 15 per cent. of hydrogen, the following being the composition by volume of these two gases:

In Fig. 4 the clam is hoisted and open, having discharged its load onto the inclined trough.



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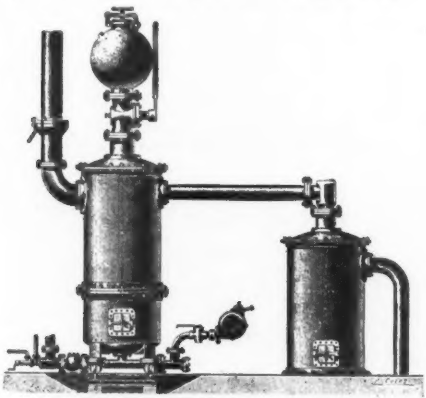

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The compressed air, led to the distributing receiver, S, fitted with the pressure-gauge, K, and safety valve, L, makes its way by the pipe, E, fitted with the stop-cock, G, into the bottom of the producer, mingled with water spray delivered by the injector, p; and a check-valve, q, at the entrance to the producer, prevents any return of the gas generated into the air receiver, the quantity of water being regulated by turning the handle. The gas issuing from the producer is led by the pipe, r, to a dry scrubber, s, for being freed from its dust, and it goes directly from this latter to the motor or furnace, as the case may be, where it is to be utilized.

The chimney, T, is only required for firing up the producer, and when, on the latter being started, the gas burns regularly at the chimney entrance, all the apertures are to be closed and compressed air admitted, when gas will be produced continuously in proportion to the volume of air. Owing to the water spray, the clinker adheres so little to the producer sides that it can be easily removed; and, as the air pressure is constant, the volume and composition of the gas do not vary, so that this producer is especially suited for providing gas to be used directly in motors. It is well adapted for large gas engines, and the floor space occupied by a producer with its accessories for a 500-horse motor does not exceed 10 sq. m. (11 sq. yds.).

Any non-bituminous coal that does not cake and contains less than 8 per cent. of volatile matter, though it may contain as much as 20 per cent. of ash, will serve for this producer; the fuel should be pea or nut size. As the whole of the fuel is turned into gas, the proportion of carbonic acid never exceeds 2 per cent., so that the calorific power is considerable, thus affording the high temperatures required in iron and glass furnaces. This arrangement is also economical, because the fuel is consumed exactly in proportion to requirements, and the production of gas ceases with shutting off the compressed air supply, so that the expenditure of gas can be strictly limited to the work it has to perform.

The use of combustible gases under pressure permits of a slow or quick working of the furnace, as may be required; and the use of compressed air as the supporter of combustion permits of regulating this working, while also affording a reducing, neutral or oxidizing flame, as may be required. A characteristic of the use of gas under pressure is combustion without smoke, an invaluable feature for large towns.

The chemical composition of the gas, on which the calorific power depends, is variable at will between the two limits corresponding with (1) air gas and (2) mixed gas with 15 per cent. of hydrogen, the following being the composition by volume of these two gases:

AIR GAS.		MIXED GAS.	
CO_2	1.86	CO_2	1.75
CO	30.54	CO	30.10
CH_4	1.72	CH_4	1.75
H_2	1.70	H_2	15.00
AZ_2	64.18	AZ_2	51.40
	100.00		100.00

The calorific power of the air gas is 1,100 calories per cu. m. (about 125 B. T. U. per cu. ft.) at zero cent. (32 degs. Fahr.) and a pressure of 760 MM. (29 in.), while that of the mixed gas is 1,500 calories per cu. m. (170 B. T. U. per cu. ft.) at the same temperature and pressure. This producer can, therefore, yield a gas the composition and calorific power of which varies between these limits, the composition of the gas being varied according to requirements by suitably proportioning the quantities of air and water introduced into the producer as already explained.

The Gardie gas-producer has been subjected by M. Leroy, the French concessionaire, to several experimental trials, first at a laboratory and afterwards in small works at Ivry-sur-Seine, where it was seen working a 100-horse Charon, driving several lathes, by M. A. Lombard, Ingenieur des Arts et Manufactures, who reported the above particulars to the *Chronique Industrielle,* of Paris, from which the accompanying illustrations have been reproduced. J. W. P.

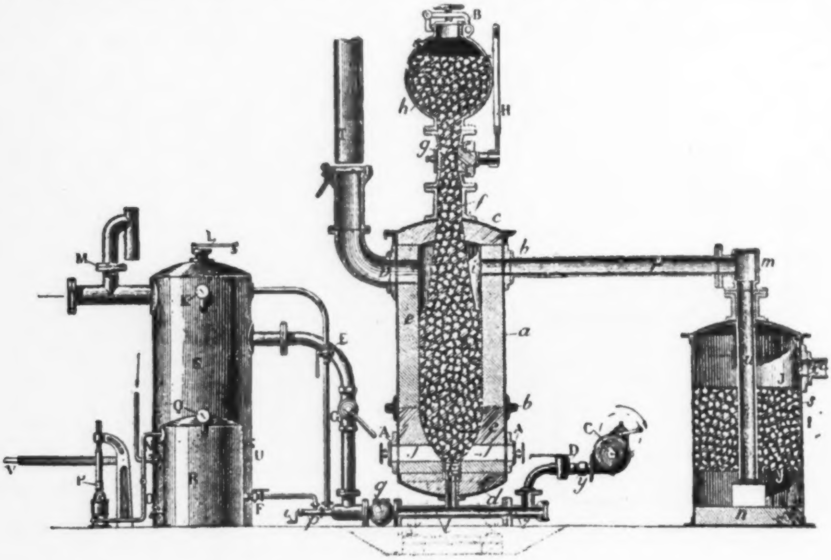


FIG. 2.

Big Rock Blasting in Wales.

Two unusually large blasts took place recently in Wales, one at the Pier Works, Goodwick. Pembrokeshire, and the other at the Welsh Granite Quarries, Trever, Llanaehairn, Carnarvon.

At the Pier, Goodwick, it took nine days to clear away the rock thrown down by the blast, so that some idea can be formed as to the extent of the fall.

Only about 7,000 tons have been cleared away, a very light impression on the mass still to be cleared. According to the original calculations, a piece of rock, 150 feet long, 120 feet high, and 60 feet deep was intended to be removed. This would mean a little over 73,000 tons. But in one direction the blast struck 100 feet further, and it is now calculated that much over 100,000 tons of rock was dislocated. Altogether it may rank as a historic blast.

The Messrs. Treglown, while they show no objection to congratulations on such a feat of engineering, place much of the credit for the successful operation to the excellent powder supplied to them by the Chillworth Powder Company. Without reliable powder the finest calculations are apt to go agley. Another tunnel for a big blast will soon be started on the Wyncliffe Hotel side of the projecting Clogwen, and the blast will take place early in December. We may say that the pier now is 600 feet long, and its grateful shelter is already availed of by coasting vessels.

The other big blast at the Trever Quarries, Carnarvon, brought down some 60,000 tons of rock.

In this blast, six tons five cwts. of black gunpowder were used, placed in two chambers. The length of the two tunnels were 90 feet and 30 feet respectively, and the fuse ignited by electricity. It is said that the quarries have been very active for some time and the men are earning high wages.

One cannot help remarking that in the granite rock blast of the Trever Quarries the heading took nine months to drive, nearly a ton more powder was used and the fall, according to estimates—more or less correct—was less than in the Pier works fall. The one driven by Messrs. Treglown, at Goodwick, occupied about three weeks or a month at most, with but one drilling machine worked by compressed air and two men. Of course, granite is harder than the rock on the pier, but even then there would seem a wide margin. It would have been interesting if the explosion on the "opposite" shore could have been heard on this side.

One huge square lump of rock is estimated to weigh nearly a thousand tons, and will require splitting before it can be tipped into the breakwater. The immense advantage of such a lump, if it were possible to dump it into the sea, is obvious.

Arctic Ice and Cold Storage Company's Compressed Air Pumping Plant.

This plant was installed February 19, 1901, for the purpose of pumping two wells, one eight inches in diameter, 225 feet deep, and the other five inches in diameter, 225 feet deep, water in both wells standing sixteen feet below the surface when not pumped. Prior to the time of installing this air plant both these wells were pumped with two Blake Deep Well Steam Pumps. The size of the pump in the eight-inch well was 9 in. by 24 in. with a 5½ in. working barrel, and the size of the pump in the 5 in. well was 7 in. by 24 in. with a 3½ in. working barrel. Both these pumps running at a speed of fifty-five strokes per minute, furnishing about ninety gallons of water per minute pumped to the surface. The water then was pumped by a duplex steam pump to a tank over their condensers, which necessitated the handling of this water twice from the well to the condensers. An Ingersoll-Sergeant class "A" compressor 12x12¼x14, equipped with a Mason governor and a Pohlé foot piece, is attached to the discharge pipes and wells. The eight-inch well is equipped with a 3½ in. discharge pipe and a 1½ in. air pipe. The five-inch well was equipped with a 2½ in. discharge pipe and a 1¼ in. air line. When the air was first used on these wells, both wells yielded about ninety gallons of water per minute with seventy pounds air pressure and compressors running about seventy revolutions per minute, and water raised to a tank fifty-five feet above surface. This condition lasted for several months, when the chief engineer, Mr. J. C. Ferguson, found upon investigation and test that from the eight-inch well he could get about ninety gallons of water per minute. So far this year number one well has been giving them all the water they require without pumping nmber two well at all. They are now getting from number one well about one hundred gallons of water per minute, compressor running seventy revolutions, at eighty pounds pressure. In connection with pumping these wells they are running seven air fans sixteen inches in diameter, with seven hundred and fifty revolutions per minute. These fans are the electric type fan with the exception that Mr. Ferguson, the chief engineer, equipped them with a wheel something similar to a water wheel, from which the fans derive their power. The size of the opening in the pipe to admit the air to the fan is 3-64 of an inch in diameter. These fans are used to furnish fresh cold air to their storage rooms, where delicate fruits are stored, and also to exhaust the foul air from

their rooms. This arrangement accomplishes all that is desired and works very nicely. In connection with their cold storage process, they keep their rooms at a very normal temperature with no evidence whatever of the foul air being in the rooms. In connection with their cold storage plant they also turn out about sixty-five tons of pure ice per day. They also have two ice machines, one a fifty and one a seventy-ton engine.

The class "A" compressor in connection with the eight-inch well furnishes all the water necessary for the condensers, both these machines, and for a coil for cooling water from the condensers. The water from this eight-inch well is delivered to the latter at a temperature of about forty-five degrees.

This plant was started the first of April of this year and has been running night and day without a stop.

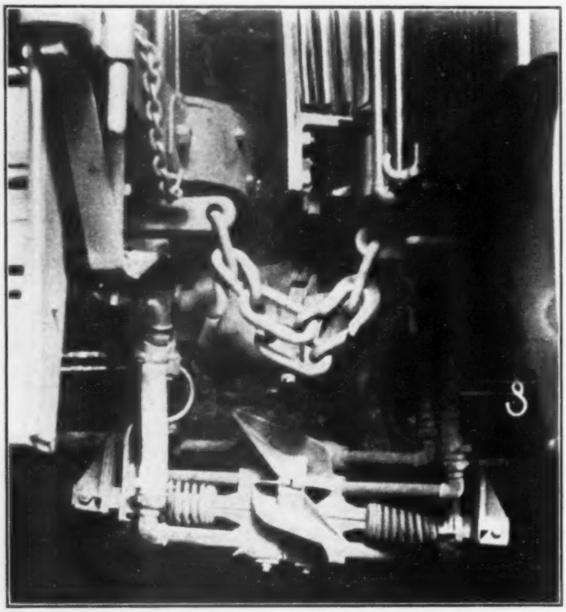
Mr. Ferguson states that he can run this compressor with about one-half of the steam consumption that is required to run the 9x12 Blake Deep Well Pump, at the same time giving about seventy-five per cent. more water.

E. P. Mooney.

The Trethewey Automatic Train-Pipes Coupling.

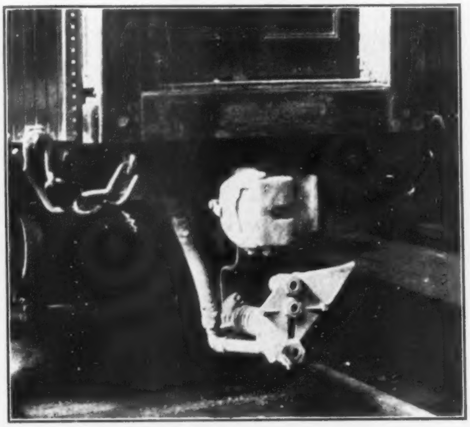
An automatic coupling for the steam and air lines on trains should be flexible, should maintain tight joints and always be positive in action. The variety of conditions met with in the service to which such a device must be subjected presents numerous obstacles to be overcome in order that the system be successful. An interesting example of one of the most recent of these devices which may be said to be successful is shown in the accompanying engravings. It is the Trethewey coupling, designed by Mr. W. G. Trethewey, of Montreal, Canada, and is now in service on trains on several roads.

The device consists of two castings, a hanger and the necessary pipes for connection to the train pipes. The head is a malleable iron casting having two diagonal guide horns, with a flattened shank at the rear. These heads are cast from one pattern and are, therefore, interchangeable. The flat sides of the shank are placed vertically. The shank projects back through a slot in the hanger and has rigidly at-



SIDE VIEW, TRETHEWEY STEAM AND AIR COUPLING.

tached at the rear end the second casting above referred to. which is a supporting bracket, the form of which may be seen plainly in the engraving. The hanger for supporting the coupling is made of a piece of flat steel ½ x 4½ in. It runs along under the stem of the coupler, from which it is supported by two U-bolts passing around the stem, each carrying on the lower end a slotted yoke, through which the hanger passes. At its forward end the hanger is semi-circularly curved and from the lower side of this curve it drops vertically, the slot through which the flattened shank of the coupling passes being at the lower end of the vertical part. The forward part of this hanger may be seen in the illustrations. Between the



END VIEW, TRETHEWEY STEAM AND AIR COUPLING.

hanger and the head is a helical spring which is under compression when the train is coupled up.

The arrangement and application of the device having been explained, the reason for its flexibility in service will be readily understood. Each coupler is supported at but one point—the slot in the hanger. When uncoupled, the shank and head are maintained in horizontal alignment by the supporting bracket on the rear end of the shank, the face of which is held against the hanger by the helical spring. As will be seen from the engraving, when the train is coupled the brackets are forced away from the hangers by the compression of the springs, permitting the heads to move freely in any direction about the points of support.

The arrangement of pipes and hose connections is apparent from the illusrations. Short lengths of pipe are screwed into the heads, extending back to points vertically below the car pipes, or approximately so, and these points are at each side of, and close to the point where the shank passes through the hanger. This arrangement permits the use of short lengths of hose: and the connections to the pipes at the lower ends being near the point around which the head moves, the hose is not disturbed by the motions of the latter.

Referring to the engraving of the end view of the car, the lower opening in the coupler head is the steam duct. This is placed a sufficient distance below the air and signal ducts so that the soft rubber gaskets used in the latter will not suffer impairment from the heat. Provision is made for the introduction of steam pressure back of the steam-joint gaskets to insure their being held tightly together in service, preventing leakage. The steam duct is also provided with an automatic drip valve to carry off condensation and prevent freezing. Arranged in the signal and steam connections are valves which are reciprocally opened by the coming together of the cars so that in switching and making up trains these parts require no attention.

For coupling with cars not equipped with this device a detachable hood is provided having ducts to register with the air and steam ports on the coupling head. At the back of the hood, nipples screwed into the ducts have hand couplings attached, to which latter the usual air and steam couplings may be connected. The device is easily and quickly attached to a car, no changing of parts being necessary, and it is claimed that an entire train can be fitted up in half a day's time.

All of the preliminary trials for testing and improving the device were made on the Canadian Pacific, and that road is so well satisfied with their experience with the device that they have decided to adopt it at once on 100 cars. The Imperial Transcontinental Limited trains of the Canadian Pacific are fitted with these couplings, and we understand that the Delaware & Hudson has three trains so equipped and the Intercolonial of Canada has ordered equipment for ten cars.

The Trethewey Automatic Steam and Air Coupling Co., Limited, Montreal, Canada, Mr. T. A. Trenholme, president, has been formed to place this device on the market.—*Railroad Gazette.*

An Unusual Water Supply Plant.

The town of Arad, in Hungary, derives its supply of water from a gravel stratum underlying an impervious bed of clay. The wells are driven to a depth of about 135 feet and the water is raised by means of an air lift. It is then filtered by means of the Fischer system of plate filters, descriptions of which have appeared from time to time in *The Engineering Record,* passes into a storage reservoir and is then pumped into the town mains by two triple expansion Worthington pumps. Before final distribution the water passes through a large air chamber to equalize the pressure in the various mains. The following description of this plant, which combines so many interesting and unusual features, has been taken mainly from an account of the works published in *Engineering* some time ago.

The wells, of which there are two, 9 inches in diameter, are about 135 feet in depth, and pass through a layer of clay 20 feet thick, the bottom of which is about 63 feet below the surface. Below that point the material passed through is mostly gravel and sand, with a few thin streaks of clay. Each well is capable of delivering 540 imperial gallons per minute, and only one is ordinarily in operation at a time, as that is found to deliver sufficient water for the needs of the town. The supply of compressed air for raising the water is carried down the well by means of a wrought iron tube. The air issuing from the bottom of this tube through a suitably arranged connection, raises the water through the casing of the well into a small cast iron well at the surface. The compressor furnishing air for the lifts has compound steam-jacketed cylinders, two in number, each being 11 inches in diameter, the stroke of all the cylinders being 18 inches. The exhaust steam from the engine is carried to a surface condenser fixed below the floor of the engine house, the circulating water required for the condenser being supplied by connecting thereto the pipe which conveys the water from the cast iron service pipe well to the filters.

The Fischer filter plates were first devised at the city of Worms because the capacity of the sand filtration plant there had been reached and no further extensions could well be made along the old lines. The engineers in charge of the works, noting that the actual work of purification was effected by the top layer of sand, 3 or 4 inches thick, set to work to devise a means of supporting this filtering film in a manner more economical of space than by means of a horizontal bed of sand. Their studies resulted in the production of a hollow artificial stone block about 39 inches square and 8 inches thick, the interior space being about 0.8 foot wide.

These blocks or plates are made of quartz sand carefully washed to free it from clay or earthy matter and then mixed with powdered glass. This mixture is placed in suitable molds and burnt at a temperature of from 1,800 to 2,100 degrees Fahrenheit. By this means the glass is melted and binds the grains of sand together without filling the interstices to an appreciable amount.

In the filter chambers the plates are placed vertically in the water, thus giving a considerable filtering surface, though occupying a small area, and the plates being hollow, the filtered water, which accumulates in the interior, is removed by means of pipes to the filtered water reservoir. The operation of cleaning is effected in the simplest manner in the case of the Fischer plate filters, by reversing the direction of the flow, thus allowing the filtered water to percolate through the plates from the inside to the outside, which is said to clean the surface of the plate in about ten minutes. An installation on the Fischer system, it is stated, only occupies one-eighth of the space required for a sand filter of equal filtering capacity.

In the works at Arad there are four filter chambers with concrete walls and floors, each 27 feet long by 10 feet 2 inches and 12 feet 2 inches deep. They are covered over with brick and concrete arches similar to those used for the filtered water reservoir. Each of the chambers contains 100 filter plates placed on edge in two tiers, each two plates being connected at the top to the horizontal collecting pipes running lengthwise of the chambers. In the inlet chamber an overflow pipe is arranged so that the level of the unfiltered water will not exceed a fixed height. The col-

lecting pipes for the filtered water are connected in a central valve chamber to the force main for the purpose of cleaning the filters. At the other end of the valve chamber are the two outlets into the filtered water reservoir, which is divided into two sections with a total storage capacity of 66,000 imperial gallons.

From the reservoir the water passes through a 12-inch pipe into the pump well sunk in the basement of the engine house, the pumping engine and the air compressors for the air lift being housed in the same room. The water is pumped from the well into the town mains, by means of two triple expansion Worthington pumps, each having six steam-jacketed steam cylinders in three pairs of 6, 9 and 16 inches diameter respectively. The pumps are provided with surface condenser and two double-acting water plungers of 10 inches diameter, all having a uniform stroke of 15 inches. Each pump is capable of delivering 666 imperial gallons of water per minute against a head of 125 feet. From the main pipes the water raised is carried into and through a large air vessel of wrought iron 20 feet high by 5 feet in diameter, for the purpose of equalizing the pressure on the town mains; and, as an additional security, a safety valve is attached to each of the town mains (in duplicate) leading from the air vessel. For the purpose of supplying steam for the steam-engine, the air compressors, and the various pumps, two marine type boilers are provided.

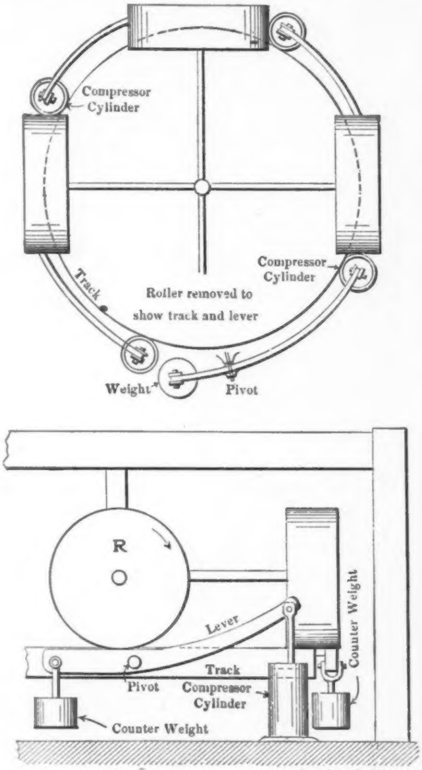
In connection with the compressed air lift an arrangement for intermittent working is used which suits cases like that at Arad, where the supply of water flowing to the well is not sufficient for constant working. Messrs. Hughes & Lancaster, of London, were the engineers and contractors for these works.—*The Engineering Record.*

A "Power Multiplying" Air Compressor.

In a small shop in the Middle West, some weeks ago, I found a machine that may interest your readers enough to excuse me for describing it. It was called an "air compressor," but so far as my knowledge of such things goes it stands alone.

Abstract of a letter written to *American Machinist.*

The sketch is intended only to illustrate the principal parts and their general arrangement. The machine consists of a vertical shaft driven by a steam engine, through a suitable arrangement of shafts and bevel gears. This shaft stands in the center of a circular track about 14 feet diameter, and carries four equally spaced radial arms about 2½ feet above the track. These arms each carry on their outer ends



A POWER MULTIPLYING AIR COMPRESSOR.

a huge, cast-iron, cheese-shaped wheel or roller. These rollers rest on the track and are made to move around the central post more by a wondrous arrangement of chains and chain wheels than by the strength of the radial arms. No attempt is made to show the chains, as they are only a minor detail. The rollers are broad enough on the face to overhang the track

and act as depressors for the air compressor pistons by over-riding the long lever attached to each piston as shown. When the machine is in motion, the rollers, moving in the direction indicated by the arrow, will each depress a piston and send a charge of compressed air through a suitable system of pipes to a reservoir common to all four cylinders. The counterweight at the short end of the lever returns the piston to its former position, ready to meet the next roller.

What I have already told may seem somewhat novel, but when you are told that the application of 10 horse-power to this machine will give a return of 100 horse-power at the reservoir, I am sure you will admit the machine is unique. On making some inquiry about the wonder, I was told that a real-estate man had put $15,000 into it. Possibly a *real-estate* man can get it out. WM S. ROWELL.

[The device here shown is practically identical with one built a few years ago at Bridgeport, Conn., on a much larger scale, financial and otherwise, which we described and commented upon at the time. As long as the atmosphere endures there will probably be those who can be caught by these something-for-nothing devices for compressing it.—Ed.]—*American Machinist.*

A New Means of Using Compressed Air in the Manufacture of Glassware.

In the production of hollow glass vessels there have always been two obstacles which from time immemorial have very seriously hampered the glass-blower. Of these obstacles, the first is that the inlet opening of the hollow vessel can never be larger than the end of the blowpipe. The second is that the hollow vessel thus produced can never be greater than the volume of air which a strong man can blow through the pipe, or the mass of glass which he can conveniently handle. The first obstacle has been partially, though indifferently, overcome by subsequent reheating and manipulation. By spurting water through his blowpipe, the glass-blower has succeeded in producing fairly large receptacles, for the expansive force of the steam generated assists the air from his lungs. But despite these ingenious makeshifts it has not been possible to blow a glass receptacle larger than a carboy having a capacity of 25 gallons.

Since the glass-blower's lungs have but a limited power, it was but natural that inventors hit upon the idea of employing compressed air. Philip Arbogast, of Pittsburg, as early as 1881, took out a patent for an invention which contemplated the use of compressed air and which has served as a foundation for subsequent attempts. But although compressed air has been widely employed in the manufacture of certain articles, it has never supplanted the human glass blower, particularly in the making of large receptacles.

A German inventor, Paul T. Sievert, now comes to the fore with a process that bids fair to solve the problem of blowing large vessels and overcoming the difficulties which have hitherto baffled the glass manufacturer. By means of this new process vessels varying in size and shape from the tiniest watch-glass to the largest bath-tub can be blown with a facility which has never been hitherto attained. That the Sievert process is capable of fulfilling these claims has been clearly shown. Many of these vessels can be completely blown without any subsequent grinding or cutting. The time in which these receptacles are made is almost incredible. The production of a bath-tub is a matter of not more than five minutes. Several days in the cooling oven is, however, still required before the tub is ready for use. Moreover, the process of making these vessels is singularly clean. No rubbish heap of broken glass is to be seen anywhere in the Sievert plant in Dresden.

The apparatus employed, by which glass is blown into pots and tubs of any size, consists of a thick, perforated cast-iron plate having the form of the opening of the tub to be produced. On the raised margin of the plate a separable frame is placed, held in position by locking-levers, which frame serves the purpose of confining the outer edge of the glass mass within the limits of the cast-iron plate. The combined plate and frame are mounted on a hollow shaft, journaled in suitable bearings and arranged to turn. By means of the hollow shaft and the perforated iron plate, compressed air can be forced into the molten glass. From a ladle suspended from a traveling-crane a sufficient quantity of molten glass is poured on the iron plate.

The liquid glass flows over the entire

plate and beneath the superposed frame surrounding the plate. Since the metal cools more rapidly at the margin, the glass begins to congeal and stiffen first at its outer edge. When this marginal rigidity has been reached, the entire plate and frame is turned through a half circle. The glass lies on the plate in a smooth, glittering layer. It is still hot, but not self-luminous; and for that reason its color is black in our pictures.

The glass no longer rests on the plate, but hangs therefrom, supported by the chilled and now rigid outer edge. But the central portion being still ductile and plastic begins to sink. In order that the glass may thus fall uniformly throughout its mass, a bed-plate, operated by rack-and-pinion and a chain-gear, is brought into contact with the slowly sinking bag of plastic glass. Upon this bed the glass spreads and forms the bottom of the tub.

By allowing the bed to fall slightly the glass is pulled down and the walls of the tub formed. The glass has become cool and tough by this time. Through the hollow shaft and the perforated iron plate compressed air is now forced into the forming tub, the operator so controlling the current that the tub's walls can be given any inclination. When the tub has been given the desired form the air blast is cut off.

In order to release the finished tub from the perforated iron plate the parts of the superposed frame (now, however, located beneath the plate) are separated by means of the levers previously mentioned; the bed is allowed to descend still further; and the finished bath-tub, rigid, though still hot, is liberated from the grip of the frame and iron plate. The hot glass tub is now hauled on a cart to a cooling oven.

In exactly the same manner a glass receptacle of any size or shape can be blown. The weight of the plastic mass is no longer a hindrance to the glass-blower; it is even utilized in the production of the finished product.

The Sievert process is not limited to the making of pots, trays, tubs, bottles, and like utensils. It seems destined to have no small influence on our methods of making plate-glass. From the recent articles which have appeared in the *Scientific American,* our readers will understand that the window-glass which we employ is rolled out and then polished. Herr Sievert, however, intends to dispense with all rolling machinery and to blow his plate very much as he blows his bath-tubs and pots. So far as we are at present informed two methods are pursued in blowing plate glass.

The first of these methods consists in blowing a cylinder after the manner previously described; in allowing this cylinder to cool; in cutting it lengthwise into two parts and severing the bottom from the body; and in causing these severed portions to flatten into plates by the application of heat. The second of these methods consists in blowing glass into the form of a huge box by means of a cubical mold and in breaking away the five plates formed by the bottom and sides. This box represents a gigantic bubble of glass 4 feet high and 5 feet wide, the thickness of the walls being somewhat more than one-tenth of an inch.

Although the Sievert process can be followed in blowing all kinds of receptacles, it is found in actual practice in the making of small utensils that the glass chills too quickly to be blown into shape. Another method has, therefore, been devised no less ingenious than the first.

We all know that a drop of water that has fallen upon a hot object—a stove, a glowing sheet of glass—does not come in contact with the hot surface, for the reason that it is buoyed up by a cushion of vapor. Nor does the drop boil rapidly away. It is slowly converted into steam and then gradually disappears. This "caloric paradox," as it is sometimes called by physicists, is profitably employed by the glass-blower; for, the water does not cause the glass to crack, and generates enough steam to assist in expanding the vessel at the end of the blow-pipe. Upon the same phenomenon Herr Sievert bases his method of forming small glass utensils, reversing it, however, by placing his hot glass on a layer of water instead of blowing water into his hot glass.

In order to make a developing tray such as every photographer uses, very hot and therefore very liquid glass is poured on a sheet of wet blotting paper. The glass does not touch the paper, does not even scorch it, but dances on the wet surface as it flows in all directions. By means of a wet roller, such as every housewife uses in flattening dough, the glowing mass is distributed evenly in a thin layer. The plate thus formed is lifted with a pair of tongs and laid on a sheet of wet asbestos

upon which it still continues to dance. Upon the plastic plate a mold of the tray to be produced is then placed. The steam generated, which is the cause of the restlessness of the plate, then forces the plastic mass up into the mold. The tray is finished. And thus it is possible to produce a glass vessel of any shape whatever.—*Scientific American.*

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

Joplin, Mo., Sept. 22.

Editor COMPRESSED AIR, New York:

Dear Sir: I read with much interest your editorial on the "Abuse in the Use of Compressed Air," which appeared in the September number of your magazine. Thinking it would interest you, I call your attention to a similar case which recently occurred in the Joplin lead and zinc district of Southwest Missouri.

In a lead and zinc mine operated by Col. Thomas J. Steers several years ago, all of the drill runners were strong, well-built men, and high-grade machine runners, having had considerable experience in mine and tunnel work throughout the country. The rock was a very hard blue flint and as a rule the drilling was done without water. After three years of hard and constant work some of the men had to give up, owing to weakness, accompanied by a slight cough. It was soon noticed that all the men were affected in the same way, and within eighteen months twelve of them died with the same disease (said to be miner's consumption, brought on by flint dust in the lungs). This case was particularly noticeable owing to the fact that all of the men were employed as drill runners in the same mine and were above the average in physical health and strength. Yours truly,

A. A. BONSACK.

Notes.

In compressing air to high pressure, so much heat is generated that, without suitable means of cooling the cylinders an explosion of the oil used to lubricate the compressor is possible.

The Philadelphia & Reading is to install a new interlocking plant of 36 levers at Norristown, Pa., and one of 56 levers at Bridgeport, Pa. In both cases the contract is given to the Pneumatic Signal Company, of New York and Chicago.

J. G. Slatter, 68 Victoria street, London, S. W., has patented a device which consists in propelling a vehicle by pneumatic transmission and employing any suitable form of combustion engine to compress air, which is used to work an expansion engine propelling the vehicle.

Messrs. Manning, Maxwell & Moore, 85-89 Liberty street, New York, are building new shops at Plainfield, N. J., which will be devoted to the building of an entire line of compressed air machinery, consisting of air compressors, pneumatic hoists and railroad tools. The principal machine shop will be 100x500 ft.

Chas. G. Eckstein of Berlin, Germany, Importer of American Machinery, especially pneumatic tools, has arrived in this country for a short visit. Domestic Manufacturers in the machinery line, who wish to communicate with Mr. Eckstein on business matters, should write to his New York office, 249 Centre Street.

News from Summitville, Ind., informs us that despite the recent decision of Judge Ryan enjoining the Richmond Gas Company from using compressors or any machinery for forcing gas pressure, the big pumping station of the Consumers' Trust Company of Indianapolis, is active. The station has two big compressors driven by gas engines, and every preparation has been made for the winter.

The North-Eastern Railway Company at Tyne Dock have installed an electro-pneumatic signalling system by Messrs. McKenzie and Holland. It consists of two electro-pneumatic frames, one of 71 levers and the other of 35 levers, and it is estimated that if the old style of mechanical locking had been adopted a cabin containing not less than 259 levers would have been required.

The compressed air water-lifting system carried out by B. A. Well Works, 145 Queen Victoria street, London, is now used by a large London brewery. Just fancy! No pump or pump rods, no valves, no machinery down within 25 feet of bottom of well or in any portion of the well. All machinery is on the surface, and that consists only of an air compressor. The only things below the surface are the rising main and the pipe for compressed air.

Lecturing before the French Society a few nights ago on the adaptability of liquefied air to navigable balloons, M. Georges Claude gave it as his opinion that it can never be used for purposes of locomotion. According to a report, M. Claude finds that 20 lbs. of liquefied air only achieve results that can be secured by one lb. of petroleum. It can be used, however, for inhalation at high altitudes, and for enabling specimens of the upper atmosphere to be secured for subsequent analysis.

Coal gas is explosive when mixed with air in the proportion of one volume of gas to sixteen of air, this being the inferior limit at which combustion will take place when the gases are fired at atmospheric pressure. Any proportion between this and one volume of gas to four of air may be ignited at atmospheric pressure. The best mixture to use in an engine is about ten to one of gas, though this is necessarily subject to variation on account of the different qualities of gas produced from coals of different grades.

In the Galena-Joplin lead and zinc district power drills are largely taking the place of hand drills, but as they are as a rule operated by steam instead of air, considerable inconvenience and trouble are experienced in their use. When a mine is large enough or is connected with a mill, and an air plant is installed, the most satisfactory results are obtained. As the formation is so extremely variable in hardness, it is difficult to give an average speed, but a range of from 3 to 6 feet per hour is common for a hole 1¼ inches in diameter.

At the convention of the American Electro-Chemical Society, held at Niagara Falls, Sept. 15, the question arose as to the proper system of pumping liquids, or, more broadly, that of handling and treating liquids. It is a simple one in general, but becomes a very difficult one in the case of electrolytic work. A number of the gentlemen present advocated the air-lift system for handling liquids such as described. It was said to be of almost universal applicability, and to be of particular value when the aeration and resulting oxidation of the solution is advantageous.

What will they not use compressed air for next? Here is a fire brigade in Southwark Bridge Road, London, with a new fire ladder. The appliance, consisting of a three-section light, telescopic steel ladder, which in less than a minute can be raised to a vertical position of eighty feet. The motive power is carbonic acid gas, mixed with compressed air, stored in cylinders. The total length of the appliance when lowered down is 26 feet. The machine was manufactured in Frankfort, by a German artillery captain (who is now chief inspector of the city police) and was manipulated with great success by two firemen after they had only received ten minutes' instruction.

A contract has just been signed between the British Pneumatic Railway Signal Company Limited and the London and South-Western Railway Company, whereby automatic and power signalling will be installed on the company's main line between Woking and Basingstoke—a distance of twenty-four miles. The installation contracted for includes eight pneumatic interlocking plants, averaging seventy levers each, and thirty-one sets of automatic signals to be erected on bridges spanning the four tracks of the railway. The basis of the installation is to divide the line between the points named into 1,000 yards sections, thus more than trebling the number of sections now existing.

A pneumatic rock scraper is an appliance in use on a gold dredger. The dredger on which it is used consists of three pontoons, instead of two, so that two wells are provided. One well accommodates the bucket ladder, the other the pneumatic scraper. The apparatus consists of an iron tunnel, swinging upon an axle, which allows the lower end of the tunnel to be raised or lowered at will

down to a depth of 65 feet. The tube is let down flush onto the bottom after the buckets have done their work, and the water is then expelled by pneumatic pressure. Men can then enter the tunnel and work at the bottom, scraping out the cavities in the rock which can not be reached by the buckets.

The engineering department of the North British Railway Company have made a vast improvement of late in their Cowlairs locomotive work-shops in connection with the use of compressed air for hand-drilling the sides of the locomotives and other pieces of machinery. The air is forced into a tall receiver, from which it is delivered under pressure to suitable spots by two-inch and one-inch pipes, which are eventually connected up to the drilling machine, the working of which is done by two workmen. Each of these drilling machines does the work of at least six skilled workmen. The friction caused by the long carriage of the air does not seem to diminish the drilling power to any material extent. The drilling machine is an American invention.

In speaking of the capacity of a certain compressed air plant as being equivalent to forty drills, this power is true of the machinery only at sea level. The altitude of Rossland, B. C., being 3410 feet above sea level, means the pressure of the atmosphere is not equivalent to a column of mercury 30 inches in height, but to one of something less than 27 inches, hence the mechanical power of the engine has first to overcome this greater tenuity of the air before it can begin to compress the atmosphere to a greater density, so as to develop power at the drills employed. The size of the drills also makes a difference. The power of a compressor at sea level and calculated to work steels 2½ inches in diameter, which can be expressed at forty drills, would in Rossland, at a higher level, with a larger drill, be better expressed by a 22 per cent. reduction.

The Sandycroft Foundry Co.'s air compressor is an electrically-driven air compressor, has cylinders 8 in. diameter by 12 in. stroke, and is running at 110 revolutions per minute. It is fitted with "Daw" patent balanced valve gear, in which the valves are controlled and balanced by the fluid pressure, thus enabling the compressor to be run at a high speed with a minimum of wear and tear. The compressor is fitted with an automatic unloading device, by which, when the receiver pressure reaches any desired limit, the piston of the compressor is put into equilibrium and the compressor runs light until the pressure falls, when compression recommences. The motor is of the four-pole semi-enclosed type, capable of developing 14 b. h. p. at five hundred revolutions per minute. It is supplied with current at a pressure of five hundred volts. The enclosed starting switch used with this motor is a new type of liquid switch recently introduced by the Sandycroft Foundry Co., Limited, of Chester, who exhibit this compressor. The makers state that practically no evaporation of the liquid takes place, and that sparking is impossible. It is provided with "no voltage" and "overload" automatic releases.

Solomon says there is "nothing new under the sun," but then Solomon did not live in 1902. A new hose coupling has been put on the London market by Lacy-Hulbert & Co., which firm make a specialty of designing and contracting for compressed air installations. They claim that in the "Boreas" coupling, as it is called, the hose is so firmly compressed that air or liquid under pressure cannot enter between the layers of the fabric and so cannot disintegrate the hose. The construction and action are as follows: A nipple (provided either with a plain screwed end or with a union nut) is inserted in the end of the hose; this end is surrounded by a conical bush, split into four segments, and contained in a conical sleeve, which is provided with a bellmouth of appropriate radius. By screwing up the nut, the cone, and through it the end of the hose, is compressed on the nipple, and is thus securely held in position. The bellmouth, it is claimed, prevents abrupt bends and the consequent damage to the hose. The coupling is made in sizes to fit hose of from ⅞-in. to 1¾ in. external diameter.

It has been known for some time that experiments have been proceeding with a view to the adoption of pneumatic tools on British men-of-war. We are now in a

position to announce that the order for the first complete installation for this purpose has been intrusted to the International Pneumatic Tool Company of London, whose works are at Chippenham. The plant is shortly to be placed on board H. M. S. "Assistance," which it is intended shall act as a workshop to the fleet in time of peace, and it is being fitted up with this object. The installation, so we gather, is to consist of a motor-driven air compressor, drills and hammers of various types, air receiver, piping, etc., all designed for the special conditions under which they will have to work, and so arranged that they will be available for use within a few moments of switching on the motor. The whole idea reflects great credit on the Admiralty, for such a repair ship as it is evidently intended to make the "Assistance" should prove of immense value, particularly during manœuvres. The addition of a pneumatic tool installation should greatly add to its effectiveness, for it will enable work to be carried out in places otherwise inaccessible. There is every indication that pneumatic tools have a wide field of usefulness on board ship—not only on warships, both in times of peace and war, but also in the mercantile marine.

We are all tunnel mad, there is no doubt about it; here they are turning up everywhere. The one in Chicago built 40 feet below the surface of the street, has been making great progress.

All this work of excavating and forming has been done under an air pressure of 10 pounds to the square inch, this pressure serving to hold back the water, at the same time making a perfect setting for the concrete. Air compressors and reservoirs were installed at each shaft, and a system of perfect air locks was placed at the bottom of each shaft and at the mouth of the tunnels leading therefrom. The construction of these air locks, whereby material could be admitted to the tunnels or taken out without disturbing the pressure, is familiar to our readers.

The construction work has been remarkably successful. A walk of hours can be made through the tunnels without any inconvenience. The walls are clean and white, with a perfectly smooth surface, and the air is pure and wholesome.

Three million dollars have already been expended, and seven millions more will be spent in completing the work. The enterprise has now progressed so far that a slope, which has its mouth on the river near Congress street, will be used for the removal of all excavated clay. There it is dumped into scows and towed away by tugs.

Advantages of Compressed Air.—1. It can be taken by pipes to any point and used there expansively, just the same as steam, and in the same engines.

2. The pipes and the air are cool and the air loses practically nothing by transmission, except by leakage and a slight drop of pressure from friction in transit.

3. The exhaust is cold, invisible and wholesome, being free air at a low temperature, which may be much below freezing point; a welcome help to ventilation.

4. The engines, being cool, are easy to lubricate and to handle.

5. The air does not corrode the pipes internally.

6. No part of the compressing plant need be in the pit—in fact, it is almost always on the bank.

7. The cost of it can be kept down easily to that of steam as a motive power if properly installed.

For a moment let us see how this compares with steam, electric or hydraulic power.

Steam requires boilers, usually below ground. These introduce heat where it is already too hot, the steam pipes and motors are hot, their exhaust is a cloud of hot steam, slow in dispersing and condensing; in fact, impossible to use in detail in the headings and roads for haulage and pumping. Steam engines are, therefore, only usable near the upcast shaft where the heat and exhaust can be got rid of.—*Coal and Iron Trade Review.*

The Batcheller Pneumatic Tube Co., of Philadelphia, has submitted proposals to the French government for equipping Paris and other large French cities with underground pneumatic conduits for intramural transmission of mails. After some days' consideration the minister of posts and telegraphs appointed a technical commission to investigate the project. The correspondent is assured that the commission is already disposed to report favorably regarding the idea as likely to obviate the delay and inconvenience

caused by mail wagons in the congested thoroughfares of the city. The commission is already greatly impressed by the fact that the new system promises a greatly accelerated service such as has been long desired in Paris. One of the strongest arguments laid before the commission is the discovery that the complicated underground electric railway in Paris has not proved a solution of the difficulty, as was hoped, since it is too slow and necessitates too frequent loadings and unloadings. Should the Batcheller plan be adopted, however, the Metropolitan underground line would be utilized for the passage of tubes. The commission asked for details regarding the success of the system, which is now working in several American cities. The company has sent a representative to Berlin and St. Petersburg, where it has been asked to explain the system with a view to its adoption for government use.

At the works of the American Steel Hoop Company much trouble was found in handling long lengths and in getting the pieces fast enough from the mills. The pulling out by boys limited the length of the pieces, the speed of the mills and thereby the product, and on hot days the boys sometimes refused to work. The roller conveyors, of which a number of different types were tried, while better than pulling out by hand, necessitated frequent repairs and stoppages, worked too slow, and were unfit for long lengths. These troubles were overcome by the Vollkommer pneumatic conveyors, which were a success from the beginning. A pneumatic conveyor 375 feet long was installed at a cost of less than £1,000, against a roller conveyor system offered for £5,000. At present the American Steel Hoop Company have eight pneumatics in operation and more under construction. The principle of operation of the conveyor is very simple.

Air from a fan at low pressure is driven into a conduit, or air box, from whence it escapes through the air ports in the running plate or face of the conveyor, forming an air cushion on which the strips float without friction. Theoretically for each 1-8 inch thickness of plate a pressure of 1 1-8 ounces is required; in practice, however, a small excess of pressure is needed, the more the narrower the strips are. It will easily be understood that they will work still more economically on wider material than on narrow band iron, where the air can easily escape sideways. In most cases the running groove was laid into the level of the mill floor instead of having it raised, and one can walk or drive over it when it is in operation. It also does not obstruct the mill for rolling other shapes, as bars, rounds, etc., which may be run out in the same groove without air pressure. The American Steel Hoop Company have acquired the right for sizes up to 8 inches, while Mr. T. J. Vollkommer, the patentee, of Pittsburg, has still the right for wider sizes.

The past few decades of this country's history has been replete with wonderful enterprises and the advances made in architectural and mechanical lines alone has been almost phenomenal, owing principally to the numerous labor-saving devices which have been and are continually being originated in the fertile minds of inventors and by them placed on the market for the mutual benefit of humanity and, in most cases, themselves also.

Among these inventions one which has proven of vital importance to the mechanical world in general, is the use of compressed air as a motive power and in connection therewith the various pneumatic appliances, such as drills, hammers, riveters, hoists, etc., which now with but slight effort do the larger portion of the work which was formerly slowly and with infinite labor performed by hand. Even the most skeptical would be convinced of this fact should they visit any of our principal shipyards, foundries or railroad shops and observe the methods of reaming, caulking, tapping, chipping, drilling, riveting, hoisting, etc., now in use and contrast them with the laborious hand methods formerly in practice.

In this connection one fact is brought prominently to mind, and that is—to invent and patent an idea is one thing and to secure the confidence of the public at large and force them to see the benefit to be derived from a practical use of this invention is another; and while, of course, great credit must be given the inventor and originator of the pneumatic tool idea, yet to those whose energy and untiring efforts have brought these tools into prom-

inence and caused the general public to become familiar with the benefit and advantages to be derived from their use, just credit must also be given, and undoubtedly the Chicago Pneumatic Tool Company, whose recent European negotiations have again brought them into public prominence, deserve the wonderful success which has fallen to their lot.

The career of this company has indeed been attended with astonishing results. Commencing, as they did, at the very foot of the ladder, they have risen with rapid strides until to-day they practically control the pneumatic tool business of the entire world and have also gained the good-will of all concerned by their fair and impartial methods of doing business.

U. S. PATENTS GRANTED AUG. 1902.

Specially prepared for COMPRESSED AIR.

706,004. PNEUMATIC MOTOR. Gustaf B. Anderson, Chicago, Ill. Filed Aug. 2, 1901. Serial No. 70,607.

The combination with a casing having a central opening and air passages and chambers communicating therewith, of valves to open and close said passages, two bellows located in said opening, means to inflate and deflate a portion of each of the bellows alternately, a power wheel or pulley journaled near the casing and means connecting the pulley and bellows whereby the pulley is rotated, substantially as described.

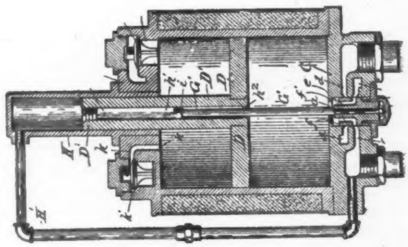
706,021. DEVICE FOR INFLATING PNEUMATIC TIRES. Frederick W. Claesgens and John G. Magin, Rochester, N. Y., assignors of one-third to George A. Claesgens, Rochester, N. Y. Filed Feb. 15, 1902. Serial No. 94,280.

706,037. PNEUMATIC STACKER. John H. Elward, Pretty Prairie, Kans., assignor to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Original application filed Jan. 5, 1893. Serial No. 457,328. Divided and this application filed Dec. 9, 1901. Serial No. 85,253.

706,050. MIXING-VALVE FOR GAS OR GASOLENE ENGINES. Roy E. Hardy, Detroit, Mich., assignor, by mesne assignments, to Hardy Motor Works, Limited, Port Huron, Mich., a Corporation of Michigan. Filed May 6, 1901. Serial No. 58,-864.

706,252. AIR-BRAKE. Frank A. McKelvey, Knoxville, Pa. Filed June 17, 1901. Serial No. 64,881.

706,276. COMPRESSOR. John Stumpf, Berlin, Germany. Filed May 9, 1901. Serial No. 59,514.



In a steam actuated aeriform-fluid compressor, the combination of a single cylinder forming both the steam-chamber and the compression-chamber, a piston working in the cylinder exposed on one side to the steam and performing on its other side the work of compression, a steam inlet and outlet slide-valve, means for positively moving the valve consisting of a stem connected at one end to the valve and provided at its other end with a shoulder, said stem being movable in a chamber in the piston, a shoulder at the lower end of the chamber adapted in the upward movement of the piston to engage the shoulder on the stem to close the valve, a shoulder at the upper end of the chamber adapted in the downward movement of the piston to engage the end of the stem to open the valve, and piston-returning means opposing the force of the piston-moving means.

706,291. SYSTEM AND APPARATUS FOR TRANSMITTING CARRIERS IN PNEUMATIC-DESPATCH TUBES. Birney C. Batcheller, Philadelphia, Pa. Filed Nov. 3, 1899. Serial No. 735,652.

706,293. PNEUMATIC TREAD OR TIRE. Frank L. Beamond, Sutton-Coldfield, England. Filed Oct. 11, 1901. Renewed July 9, 1902. Serial No. 114,961.

706,363. AIR-BRAKE ATTACHMENT. Arthur L. Tibbits, Chicago, Ill. Filed Nov. 15, 1901. Serial No. 82,432.

706,425. HOT-AIR PUMPING-ENGINE. John T. Lally and James J. English, Wilmington, Del. Filed Jan. 28, 1902. Serial No. 91,590.

706,454. CARBURETER. Clark Robinson, Hartley, Iowa. Filed Jan. 27, 1902. Serial No. 91,436.

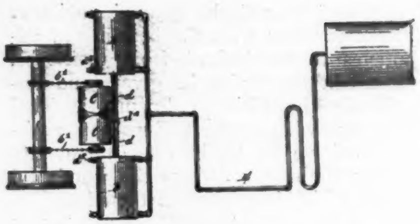
A carbureting apparatus comprising in its construction a chamber containing carbureting-tanks, means for introducing air into one of said tanks, a hydrocarbon-liquid reservoir, a pipe for conducting a supply of the hydrocarbon liquid to the aforesaid chamber, devices for controlling the supply, and apertures in the walls of the carbureting-tank for permitting the liquid to flow from the aforesaid chamber into the carbureting-tanks, substantially as and for the purpose set forth.

706,574. PNEUMATIC PIANO-PLAYER. Samuel B. Locklin, Boston, Mass. Filed Aug. 10, 1901. Serial No. 71,595.

In an automatic piano-player, a series of fingers adapted to operate the keys of the piano, and automatic finger-operating mechanism, each of said fingers having integral therewith a yieldable projection carrying a hammer, and an adjusting device in the end of each finger constructed to adjust the said projection relative to the finger.

706,639. PNEUMATIC-DESPATCH APPARATUS. James T. Cowley, Lowell, Mass., assignor to the American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed Nov. 27, 1899. Renewed Dec. 14, 1901. Serial No. 85,912.

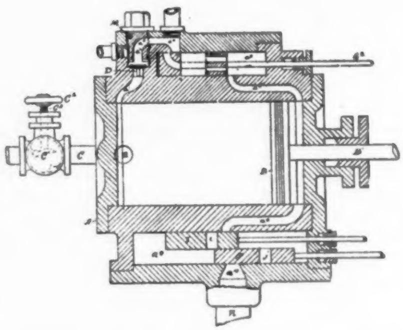
706,653. MEANS FOR UTILIZING COMPRESSED AIR. Eugene Hayward, Chicago, Ill., assignor of two-thirds to John T. Lueder and John B. Morris, Chicago, Ill. Filed Feb. 15, 1901. Serial No. 47,490.



The combination with a boiler of an air-compressor, means for operating the same, a metal-cased pipe located transversely in the fire-box and leading into the dome of the boiler and adapted to deliver thereinto heated and compressed atmospheric air.

706,716. PNEUMATIC MALTING-KILN. Bernard Berg, San Francisco, Cal. Filed Dec. 30, 1901. Serial No. 87,746.

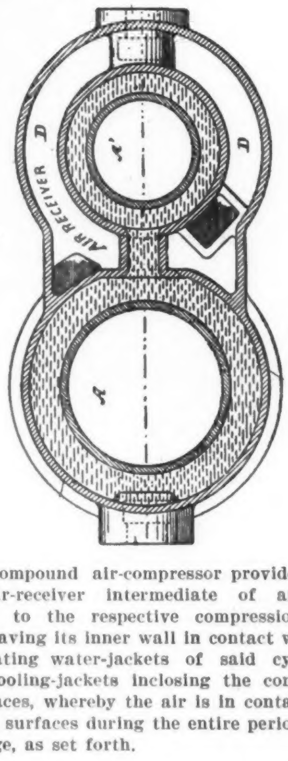
706,871. AIR-COMPRESSOR. George H. Abrams, Brooklyn, N. Y. Filed May 15, 1896. Serial No. 591,641.



In a combined air compressor and expander, the combination of a cylinder and piston for compressing air to a high tension, an outlet therefrom adapted for connection with a suitable cooling device, an inlet thereto adapted to receive the air upon its return from said cooling device, means whereby the compressed air may expand in the rear of the piston, and suitable means whereby the air first compressed may be led directly to the rear of the piston instead of first passing through a cooling device, substantially as described.

706,944. PNEUMATIC-TIRE VALVE. Harold W. Hodgetts, New Haven, Conn., assignor of one-half to William J. Hodgetts, Wallingford, Conn. Filed Dec. 23, 1901. Serial No. 86,882.

706,979. COMPOUND AIR-COMPRESSOR. George E. Martin, Philadelphia, Pa., assignor to the Pedrick and Ayer Company, Philadelphia, Pa. Filed Aug. 15, 1901. Serial No. 72,115.



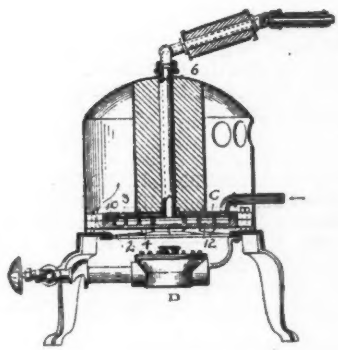
A compound air-compressor provided with an air-receiver intermediate of and adjacent to the respective compression-cylinders having its inner wall in contact with the circulating water-jackets of said cylinders, and cooling-jackets inclosing the connecting air-spaces, whereby the air is in contact with cooled surfaces during the entire period of its passage, as set forth.

707,053. AIR-FEEDING DEVICE. William D. Douglas, Chicago, Ill. Filed Mar. 5, 1902. Serial No. 96,846.

In an air-feeding device, the combination with a casing having a plurality of openings in its walls, of an outwardly and downwardly projecting collar or piece located thereon above said openings, and a skeleton frame located on the lower portion of the casing, substantially as described.

707,071. PNEUMATIC TIME-LOCK FOR PNEUMATIC-TUBE SYSTEMS. Birney C. Batcheller, Philadelphia, Pa. Filed Oct. 11, 1900. Serial No. 32,681.

707,111. COMPRESSED-AIR-HEATING APPARATUS. George W. Hopkins, Cleveland, Ohio, assignor to the Terry Heater Company, Cincinnati, Ohio, a Corporation. Filed Apr. 10, 1902. Serial No. 102,198.



In a compressed-air-heating apparatus, a hollow air-confining member having inlet and outlet pipes, a delivery-tube for the air connected with said outlet-pipe and comprising jointed sections, a discharge-tip of non-heat-radiating material at the end of said delivery-tube, and means to heat the air in its passage through said hollow member, substantially as described.

707,134. APPARATUS FOR CLEANING AIR FROM SAND-BLAST APPARATUS. Jeremiah E. Mathewson, Broad Heath, near Manchester, England, assignor, by mesne assignments, to Benjamin C. Tilghman, Jr., and Richard Tilghman, trading as The Firm of B. C. & R. A. Tilghman, Philadelphia, Pa. Filed Sept. 20, 1901. Serial No. 75,743.

The combination with a sand-blast plant and an exhaust-conduit pipe leading from said plant and adapted to draw dust-ladened air from said locality, of an exhaust-fan coupled to said conduit and a nozzle arranged to throw a jet or jets of water upon the rotating blades of the fan, whereby said water is finally divided and thoroughly mixed with the dust-ladened air.

707,246. PNEUMATIC POWER-HAMMER. Harold F. Massey, Withington, England. Filed Mar. 1, 1901. Serial No. 49,384.

In a pneumatic power-hammer the combination of a pump-cylinder and a hammer-cylinder with passages to connect the two ends of the one with the two ends of the other and furnished with openings to be opened more or less or closed in order to regulate the flow of air between such cylinders.

707,437. HOT-AIR FURNACE. Thomas J. March, Pottstown, Pa. Filed Feb. 5, 1902. Serial No. 92,729.

707,515. PNEUMATIC HAMMER. Henry J. Kimman, Chicago, Ill., assignor to the Chicago Pneumatic Tool Company, Trenton, N. J., a Corporation of New Jersey. Filed June 24, 1901. Renewed July 19, 1902. Serial No. 116,243.

In a tool of the class described, the combination of a cylinder provided with a reciprocating piston-hammer, a handle-base provided with a cylindrical projection extending into the rear end of the cylinder to close the same and provide an annular valve-chamber between it and the cylinder, and a tubular controlling-valve reciprocatingly mounted in such valve-chamber to govern the admission of the motive fluid to the cylinder, substantially as described.

707,527. SAND-BLAST APPARATUS. Ambrose G. Warren, Philadelphia, Pa., assignor of one-half to J. W. Paxson Company, Philadelphia, Pa., a Corporation. Filed Apr. 1, 1902. Serial No. 100,905.

A sand-blast apparatus comprising a closed casing or reservoir, having a substantially cone-shaped hopper-base, a sand-discharge opening therein, a communicating tubular sand-conduit leading therefrom to a combining-tube, a hand-hole opening in the inclined wall of the conical hopper contiguous to said discharge-opening therein, and a removable cover therefor; said elements being constructed, combined and operating, substantially as set forth.

12,022. PNEUMATIC STACKER. John H. Elward, Hutchinson, Kans., assignor, direct and mesne assignments, to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed May 5, 1902. Serial No. 105, 917. Original No. 688,400, dated Dec. 10, 1901.

707,634. VESSEL FOR HOLDING AND SHIPPING LIQUID AIR OR OTHER LIQUID GASES. James F. Place, Glenridge, N. J. Filed Feb. 10, 1902. Serial No. 93,289.

In a receptacle or container for liquid air or other liquefied gas, comprising an inner liquid-holding bottle or vessel and an outer case; an air-tight covering or impervious inclosure inclosing said receptacle, one part of which is infolded within itself in form of a cul-de-sac, and which serves as a lining to the inner liquid-holding bottle, and the other part or fold of which incloses a vacuum jacket or chamber around said liquid-holding bottle or vessel, substantially as shown and described.

707,661. PNEUMATIC TIRE. Moritz Weiss, Vienna, Austria, Hungary. Filed May 14, 1902. Serial No. 107,309.

707,821. AIR-PUMP. Theodore N. Case, Mount Vernon, N. Y. Filed Dec. 4, 1901. Serial No. 84,598.

In an air-pump the combination of a pumping-cylinder, a pumping-piston therein, a governor air-chamber, a connection between said pumping-cylinder and said governor air-chamber and positively-actuated means for opening said connection just prior to the opening of the pumping-cylinder descharge-ports and maintaining it closed at all other times, said means being independent of said pumping-piston.

707,911. COMBUSTION APPARATUS FOR STEAM-BOILERS. Joseph R. Fraser, Dayton, Ohio. Filed Oct. 24, 1901. Serial No. 79,828.

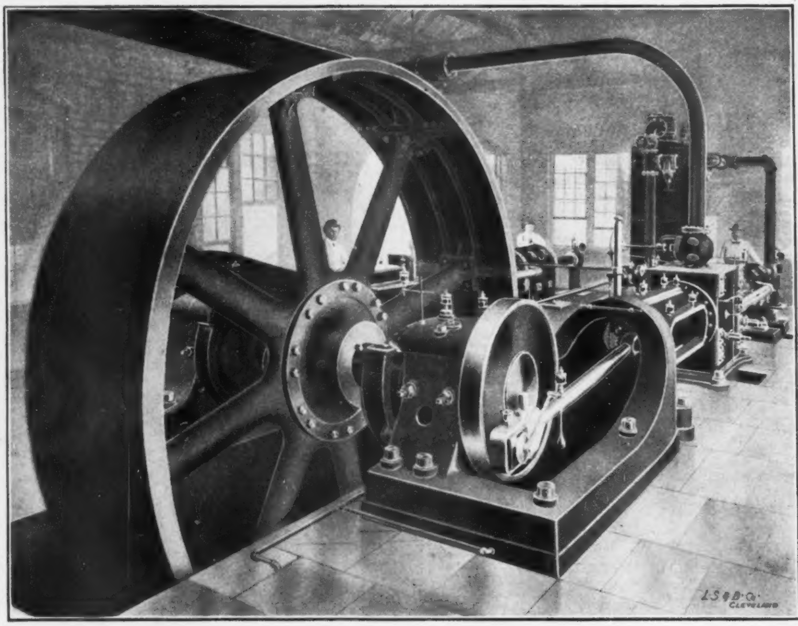
The combination with a steam-boiler, of the furnace attachment described, the same comprising an air-compressor, an oil-tank having a pipe extending thereinto, an air-pipe connecting the tank with the compressor, whereby air-pressure is applied upon the surface of the oil, a combustion-chamber,

or fire-box, extending into the boiler and opening below the normal water-level therein, an air-pipe arranged in the fire-box, and an oil-pipe within the air-pipe, both having nozzles, located in the upper portion of the combustion-chamber, which are provided with coincident end openings for escape of air and oil, and an electrical igniting device arranged in the combustion-chamber directly below the air-pipe, where the oil is atomized, substantially as shown and described.

707,920. PNEUMATIC HAMMER. Charles H. Haeseler, Philadelphia, Pa. Filed June 20, 1901. Serial No. 65,342.

In a pneumatic-hammer, the combination of a handle provided with a cylindrical portion having an internal screw-thread and a larger portion having an internal screw-thread of the opposite pitch, with a cylinder having a screw-threaded end adapted to engage the smaller screw-thread in the handle, and a nut adapted to engage the larger screw-thread in the handle.

AIR COMPRESSORS
FOR
QUARRYING PURPOSES



1000 H. P. COMBINATION CORLISS POWER AND AIR COMPRESSOR PLANT.
Designed and built by The Ingersoll-Sergeant Drill Co., for the Kelley Island Lime & Transport Co., Marblehead, O., Quarries.

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